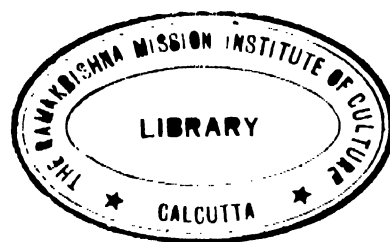19859

A SKETCH

OF THE

GEOGRAPHY AND GEOLOGY

OF THE

HIMALAYA MOUNTAINS AND TIBET

BY

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PART I ク2.

THE HIGH PEAKS OF ASIA

PREFACE

IN 1807 a Survey detachment was deputed by the Surveyor General of Bengal to explore the source of the Ganges: this was the first expedition to the Himalaya undertaken for purely geographical purposes. A hundred years have now elapsed, during which geographical and geological information has been steadily accumulating and we have at length reached a stage where there is danger of losing our way in a maze of unclassified detail : it is therefore desirable to review our present position, to co-ordinate our varied observations and to see how far we have progressed and what directions appear favourable for future lines of advance.

The present paper originated in a proposal submitted by the Survey of India to the Board of Scientific Advice at the meeting of the latter in May 1906. The proposal was as follows :—" The number of travellers in the Himalaya and Tibet is " increasing, and a wider interest is being evinced by the public in the geography of " these regions. It is therefore proposed to compile a paper summarising the geographi- " cal position at the present time."

Subject to the modification that the scope of the paper should be geological as well as geographical, this proposal has received the sanction of the Government of India and the work has been entrusted to us to carry out. On the understanding that the paper is intended primarily for the use of the public, we have endeavoured to avoid purely technical details and to present our results in a popular manner.

Our subject has fallen naturally into four parts, as follows :—

> PART I.—The high peaks of Asia.
> PART II.—The principal mountain ranges of Asia.
> PART III.—The rivers of the Himalaya and Tibet.
> PART IV.—The geology of the Himalaya.

Though the four parts are essentially interdependent, each has been made as far as possible complete in itself and will be published separately. The first three parts are mainly geographical, the fourth part is wholly geological: the parts are subdivided into sections, and against each section in the table of contents is given the name of the author responsible for it.

PREFACE

The endeavour to render each part complete must be our apology for having repeated ourselves in more places than one: the relations, for instance, of a range to a river have been discussed in Part II, when the range was being described, and have been mentioned again in Part III under the account of the river.

As the mountains of Asia become more accurately surveyed, errors will doubtless be found in what we have written and drawn: it is not possible yet to arrive at correct generalisations and we have to be content with first approximations to truth.

Maps, too large for insertion in such a volume as this, are required for a study of the Himalayan mountains: the titles of maps illustrating the text are given in footnotes and are procurable from the Map Issue Office of the Survey of India in Calcutta. Constable's hand-atlas of India will be found useful.

We are much indebted to Babus Shiv Nath Saha and Ishan Chandra Dev, B.A., for the care with which they have checked our figures and names, and to Mr. J. H. Nichol for the trouble he has taken to ensure the correctness of the charts. Mr. Eccles and Major Lenox Conyngham have been kind enough to examine all proofs, and to give us the benefit of their advice and suggestions. Mr. Eccles has also supervised the drawing and printing of the charts, and we have profited greatly by the interest he has shown in them.

S. G. BURRARD.

H. H. HAYDEN.

March 1907.

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CHART
to illustrate the TRENDS of the
principal Mountain ranges
of the
HIMALAYAN and TRANS-HIMALAYAN SYSTEMS

NOTE.—The principal ranges are represented by thickest lines; the smaller ranges by thinner lines.

Miles

(Map labels include:) Tian Shan Plateau, Issik Kul, Tarim Basin, Tarim R., Tsaidam Swamps, Tibet Plateau, Pamir Plateau, SARIKOL RANGE, KASHGAR RANGE, AGHIL RANGE, KARAKORAM RANGE, ZASKAR RANGE, GREAT HIMALAYAN, OUTER HIMALAYA, PIR PANJAL RANGE, NAGA RANGE, SULIMAN RANGE, Indus R., Kabul R., Kunar R., Jhelum R., Chenab R., Ravi R., Sutlej R., Jumna R., Ganges R., Gandak R., Kosi R., Tista R., Brahmaputra R., Subansiri R., Dihang R., Dibong R., Mt. Everest, Kali R., Chenab R., Luni R., Oxus R., Zerafshan R., Hari Rud, Murghab R., PLAINS OF INDIA, ARABIAN SEA

No. 945, 3 F S.—Oct. 08.—1,000.

THE HIGH PEAKS OF ASIA.

1

THE PRINCIPAL PEAKS AND THEIR ALTITUDES.

IN the earlier stages of geographical investigation the most important features of a mountain mass are the high peaks. They may be, it is true, but slight prominences of lofty ranges and they may possess perhaps no geological significance : but they are conspicuous and definite points ; they are the only mountain features that can be observed with accuracy from a distance ; and the determination of their positions and heights is the first step of the ladder of geographical knowledge. When this step has been taken, further progress becomes possible ; the peaks can be made the basis of subsequent surveys ; the courses of rivers and the positions of lakes can be laid down with regard to them ; the trends and forms and magnitudes of the ranges can be inferred from the distribution of the peaks.

In the following tables i to v all the peaks of Asia that have been found to exceed 24000 feet in height are catalogued in order of magnitude : their geographical positions are shown in the five corresponding charts, numbered also i to v.*

TABLE I.—Peaks of the first magnitude exceeding 28000 feet in height.

Reference number of Peak.	Name or symbol.	Height.	Number of stations from which the height was observed.	Latitude.	Longitude.†	Mountain range.
		feet		° ′ ″	° ′ ″	
1	Mount Everest ..	29002	6	27 59 16	86 55 40	Nepal Himalaya
2	K²	28250	9	35 52 55	76 30 51	Karakoram
3	Kinchinjunga I ..	28146	9	27 42 9	88 9 0	Nepal Himalaya

* Those peaks only have been included the heights of which are known with fair accuracy. Peaks the heights of which have been conjectured by explorers to exceed 24000 feet have been omitted.

† The values of longitude are based on the determination of the difference between Greenwich and Madras made in 1894-96, and are not those hitherto accepted by the Survey of India.

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TABLE V.—Peaks of the fifth magnitude between 24000 and 25000 feet in height.

Reference number of Peak.	Name or symbol.	Height.	Number of stations from which the height was observed.	Latitude.	Longitude.*	Mountain range.
		feet		° ′ ″	° ′ ″	
49	XLV	24885	5	28 44 3	83 21 51	Nepal Himalaya
50	XXXVI	24750	4	28 35 3	83 59 31	Nepal Himalaya
51	Kulha Kangri I	24740	4	28 2 49	90 27 30	Assam Himalaya
52	Karakoram No. 5	24690	1	35 8 54	77 34 41	Karakoram
53	XXXV	24688	4	28 32 11	84 5 5	Nepal Himalaya
54	Kulha Kangri II	24660	1	28 4 11	90 26 53	Assam Himalaya
55	Shyok Nubra Watershed No. 3	24650	2	34 48 14	77 48 22	Karakoram
56	Tirich Mir II	24611	2	36 25 52	71 50 11	Hindu Kush
57	Shyok Nubra Watershed No. 4	24590	2	34 50 31	77 47 16	Karakoram
58	Kunjut No. 2	24580	1	36 12 45	75 15 12	Karakoram
59†	R²⁰⁴	24496	2	28 13 52	90 37 10	Assam Himalaya
60	Indus-Nagar Watershed No. 2	24470	2	36 0 14	74 52 34	Kailas
61	LVII	24391	3	30 21 58	79 59 54	Kumaun Himalaya
62	Muztagh Ata	24388	2	38 16 43	75 7 6	Kashgar
63	K¹²	24370	4	35 17 46	77 1 23	Karakoram
64	A satellite of Kinchinjunga	24344	5	27 52 40	88 8 35	Nepal Himalaya
65	Tirich Mir III	24343	2	36 23 31	71 53 43	Hindu Kush
66	Kuen Lun No. 1	24306	2	35 47 48	81 8 42	Kuen Lun
67	XXVI	24299	1	28 23 30	85 7 45	Nepal Himalaya
68	Haramosh	24270	3	35 50 29	74 53 52	Kailas
69	Sad Ishtragh	24171	4	36 32 54	72 6 54	Hindu Kush
70	XLVIII	24150	7	28 43 54	83 12 43	Nepal Himalaya
71	Kunjut No. 3	24090	2	36 19 3	75 2 11	Karakoram
72	A satellite of Kinchinjunga	24089	5	27 47 15	88 11 55	Nepal Himalaya
73	Hunza-Kunji IV	24044	1	36 24 10	74 41 43	Karakoram
74	Chamlang	24012	2	27 46 31	86 58 56	Nepal Himalaya
75	Kabru	24002	2	27 36 30	88 6 50	Nepal Himalaya

The names adopted for the peaks are those most commonly employed by geographers. In a later section of this paper is given a list of alternative names and symbols, which have been applied to the high peaks at different times : in the same place are discussed a few geographical names that are giving rise to controversy and confusion.

Explanation of the tables.

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* The values of longitude are based on the determination of the difference between Greenwich and Madras made in 1894-96, and are not those hitherto accepted by the Survey of India.

† The position of this peak is doubtful.

A column has been included in tables I to V showing the number of stations from which the height of each peak has been observed. For the attainment of accuracy it is more profitable to observe a peak from different places and distances than to multiply observations from any one station; and the number of observing stations is an indication of the trustworthiness of the resulting value of altitude. The accuracy of the adopted values of height is discussed hereafter, and numerical estimates of the magnitudes of the errors that may exist are formed.

The latitude and longitude of each peak have been given in the tables, so that its position on the charts may be ascertained. In the drainage charts XXIV to XXXIV (appended to Part III) these positions have been marked exactly : but in charts I to V the scale is so small that in crowded clusters there has not been always room to mark the precise position of each peak; a few of the symbols overlapped, and had to be slightly displaced in order to make room for others.

It will be noticed that every peak of chart I is shown by a larger and larger circle on each of the successive charts II to V; the reason for this increase is that at the level of 28000 feet Kinchinjunga, for example, is in nature hardly more than a point, but at 27000 feet the contour round Kinchinjunga encloses an *area*; and at 24000 feet a horizontal section taken through the Kinchinjunga pyramid would show that a *considerable* area of the earth's surface had attained that elevation.*

In the last column of each table is given the range on which each peak is situated, the great Himalaya range being divided into four sections:—

(i) the Punjab Himalaya from the Indus to the Sutlej;

(ii) the Kumaun Himalaya from the Sutlej to the Kali;

(iii) the Nepal Himalaya from the Kali to the Tista;

(iv) the Assam Himalaya from the Tista to the Brahmaputra.†

The relative positions of the ranges mentioned in the tables are shown on the range chart which serves as a frontispiece.

In table VI are given the details of a few well-known peaks, which are *less* than 24000 feet in height. This table unlike the preceding does

Well-known peaks below 24000 feet.

not contain the names of all peaks above a certain height, and is not therefore a continuation of table V. Peaks have been omitted which exceed in height many of those of table VI; to give complete lists of all known peaks would be to convert this paper into a numerical catalogue.

A great many of the peaks of table VI are visible from Mussooree and Landour, and their outlines are shown in chart VIII.‡ The panorama of chart VIII is continuous from left to right: it has been drawn in three sections that it might be made to fit the size of this paper. The reference letters A and B have been added to indicate continuity.

* On chart V peaks of the fifth magnitude have been drawn as points, those of the fourth magnitude have been given a diameter of 6 miles, those of the third a diameter of 12 miles, those of the second a diameter of 18 miles, and those of the first a diameter of 24 miles.

† The Punjab and Kumaun Himalaya have been for the most part surveyed; the peaks of the Nepal Himalaya have been observed from long distances and the rivers and roads explored: the Assam Himalaya form still a *terra incognita*, although many of the peaks have been well observed from the south.

‡ This chart was copied from the panorama drawn by Col. St. G. C. Gore, C.S.I., R.E., in 1887.

TABLE VI.—Some well-known peaks the heights of which are less than 24000 feet.

Reference number of Peak.	Name in common use.	Height.	Number of stations from which the height was observed.	Latitude.			Longitude.*			Mountain range.
		feet		°	′	″	°	′	″	
76	Api	23399	3	30	0	22	80	55	57	Nepal Himalaya
77	Badrinath	23190	5	30	44	16	79	16	52	Kumaun Himalaya
78	Bandarpunch	20720	5	31	0	12	78	33	17	Kumaun Himalaya
79	Chumalhari	23930	2	27	49	39	89	16	15	Assam Himalaya
80	Chumunko	17310	4	27	27	31	88	47	12	Nepal Himalaya
81	Dayabhang	23750	2	28	15	22	85	31	9	Nepal Himalaya
82	Deotibba	20410	5	32	12	51	77	23	54	Punjab Himalaya
83	Dubunni	20154	1	35	57	23	74	38	5	Kailas
84	Dunagiri	23184	4	30	30	57	79	52	4	Kumaun Himalaya
85	Gangotri †	21700	3	30	52	58	78	52	14	Kumaun Himalaya
86	Gardhar	21140	1	32	55	7	76	42	48	Punjab Himalaya
87	Gaurisankar ‡	23440	6	27	57	52	86	20	16	Nepal Himalaya
88	Jaonli §	21760	1	30	51	17	78	51	25	Kumaun Himalaya
89	Jibjibia East ⎫ ¶	21839	2	28	7	41	85	52	16	Nepal Himalaya
90	Jibjibia West ⎭	22876	2	28	10	25	85	46	51	Nepal Himalaya
91	Kailas	22028	2	31	4	2	81	18	50	Kailas
92	Kaufmann	23000	..	39	18	20	72	50	3	Trans Alai
93	Kedarnath	22770	6	30	47	53	79	4	7	Kumaun Himalaya
94	Kharchakund	21695	1	30	46	46	79	7	47	Kumaun Himalaya
95	Leo Pargial N. ⎫ ¶	22210	2	31	54	8	78	44	39	Zaskar
96	Leo Pargial S. ⎭	22170	2	31	53	5	78	44	5	Zaskar
97	Lunkho	22641	2	36	46	36	72	26	16	Hindu Kush
98	Mer or Kana ‖	23250	2	34	0	48	76	3	22	Punjab Himalaya
99	Nampa	22162	4	30	0	37	81	0	3	Nepal Himalaya
100	Nandakna	20700	2	30	20	56	79	43	9	Kumaun Himalaya
101	Nandakot	22510	3	30	16	51	80	4	11	Kumaun Himalaya
102	Narsing	19130	4	27	30	40	88	17	2	Nepal Himalaya
103	Nilakanta	21640	3	30	43	52	79	24	28	Kumaun Himalaya
104	Panch Chulhi	22650	3	30	12	51	80	25	41	Kumaun Himalaya
105	Pandim	22010	8	27	34	38	88	13	10	Nepal Himalaya
106	Pauhunri	23180	2	27	56	56	88	50	39	Nepal Himalaya
107	Sargaroin	20370	2	31	6	8	78	30	4	Kumaun Himalaya
108	Ser or Nana **	23410	6	33	58	56	76	1	31	Punjab Himalaya
109	Simvo	22360	2	27	40	44	88	14	38	Nepal Himalaya
110	Srikanta	20120	4	30	57	25	78	48	22	Kumaun Himalaya
111	Tengri Khan	23600	..	42	24	10	80	16	43	Tian Shan
112	Tharlasagar	22610	2	30	51	41	78	59	45	Kumaun Himalaya
113	Trisul East	22320	4	30	16	14	79	52	24	Kumaun Himalaya
114	Trisul West	23360	7	30	18	43	79	46	40	Kumaun Himalaya

*The values of longitude are based on the determination of the difference between Greenwich and Madras made in 1894-96, and are not those hitherto accepted by the Survey of India.

† The twin of Jaonli.   ¶ Twins.
‡ Double-peaked.   ‖ The twin of Ser.
§ The twin of Gangotri.   ** The twin of Mer.

2

NOTES ON CERTAIN OF THE GREAT PEAKS.

MOUNT EVEREST.

The elevation of Mount Everest was first observed in 1849, but its height was not computed till 1852. Though half a century has elapsed since its discovery and the mountains of Asia have been continually explored in the interval, no second peak of 29000 feet has been found. There is but little probability now of a higher peak than Mount Everest being discovered and even the prospect of finding new peaks of 27000 or 26000 feet is becoming remote.

Some geographers have held that peaks higher than Mount Everest were standing behind it to the north, but their opinion was not founded on trustworthy observations, and when Major Ryder traversed Tibet along the Brahmaputra in 1904 he passed 80 miles north of Mount Everest and found no peak approaching it in height.

Three panoramas showing the outline of Mount Everest are included in chart VI.*

Owing to the objections of the Nepalese Government Mount Everest cannot be approached by surveyors from the side of India within 80 miles, and the trigono-metrical observations that have been made of the Everest-Makalu group of peaks have been carried out under great disadvantages. The following description of Mount Everest is taken from a report by Colonel Tanner :†

" The outline of Everest is rather tame than otherwise ; it is fairly sharp and has a long snowy " slope on its north-east flank, the south-east being precipitous. Peaks of 22000 feet and thereabouts " encircle its southern base, and below them are seen many outlines of dark mountain masses which " are without snow.

" From due south, near the Kosi river in the Bhagalpur district, Everest is by no means a marked " feature in the landscape ; its southern face has but 190 feet of snow, below which the mountain " falls for 4000 to 5000 feet in a series of crags of very dark-coloured rock, only here and there dashed " and streaked with snow, below which are snow fields and broken masses of rock intermingled " with snow and névé. When the atmosphere is not very transparent the sharp tip is seen as a " mere floating white speck, the rock below it being almost exactly of the colour of the sky and there- " fore invisible.

" The southern face of Everest from a near point of view is doubtless wild, and its cliffs must " be very lofty, but the great distance from which it is viewed renders this aspect of the mountain " uninteresting. In fact, from the south, Everest has all the appearance of a very moderate hill, not " in the least imposing and hardly picturesque. It is interesting only because by trigonometrical " operations its summit has been found to rise up further from the general level of the earth's " surface than that of any other point."

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* The panoramas from Mahadeo Pokra and Kaulia were drawn by Captain H. Wood, R.E., in 1903 : those from Darjeeling and Sandakphu by Captain Harman, R.E., in 1882. Major Ryder's description of Mount Everest as seen from Tibet will be found in the *Geographical Journal*, Vol. XXVI. "It stands alone," he wrote, "in magnificent " solitude." There is no doubt, whatever, that the peak observed by Ryder from Tibet was the same peak as had been fixed by the G. T. Survey from Bengal.

† *General Report, Survey of India,* 1883-84.

PEAK K².

The great altitude of peak K² was first discovered in 1858 by trigonometrical observations. "It was across the plains of Deosai," wrote Colonel Montgomerie, "from "Haramukh that I took the first observation to peak K² at a distance of 137 miles."

K² is described by Colonel Godwin-Austen as follows : " K² is a conical mass with "sides too steep to allow the snow to rest on them long : it lies therefore only in large "patches and stripes on the fissured surface."

Sir Martin Conway writes that K² has a double summit, which he has seen on several occasions. Colonel Godwin-Austen, however, believes it to be single-peaked.*

KINCHINJUNGA.

K² has always been supposed to be the second highest mountain on the earth, but its height does not differ much from that of Kinchinjunga, and we cannot yet state with certainty which is the higher of the two.†

The following extract is from Colonel Tanner's report for 1883-84 :—

"Kinchinjunga is a better known mountain than any in the Himalaya, and it is perhaps, "with one exception, the grandest in the whole range. It is regarded by the permanent residents "of Darjeeling with admiration that never palls, and although it is constantly, in clear weather, "a prominent object in their front, the beholder is never wearied of studying the great snow slopes "and ice fields which cover its sides.

"The aspect of the mountain has many phases which constantly alter its appearance from day "to day. It is seen to best advantage when its base is veiled in a delicate curtain of clouds, so that "the imagination is allowed to magnify the part which is hidden from view.

"From Darjeeling and from Sandakphu Kabru‡ appears as a straight-topped and "uninteresting ridge of snow, standing slightly away from the central peaks of Kinchinjunga, but at "a distance of 100 miles from points in the Purnea district of Bengal a telescope reveals the fact that "the face of Kabru presented towards Darjeeling is only one side of a huge snow-clad tableland "(24000 feet), quite smooth at the top with a very slight slope down to the westward. Kabru is "connected with the second highest peak of Kinchinjunga (27803 feet) by a ridge, the very lowest "depression of which has an altitude of 22100 feet."

In 1883 Mr. W. W. Graham claimed to have climbed Kabru, but his claim has been disputed by many authorities, though recognised by others. Colonel Tanner thought that Graham had mistaken a lower peak for Kabru.

Although the snow-line in Sikkim is lower than in the Western Himalaya and Karakoram, there are more naked spots on the slopes of Kinchinjunga than at similar altitudes on K² and Nanga Parbat.

The outline of Kinchinjunga as seen from Darjeeling is shown in chart VI.

* *Geographical Journal*, Vol. III, pages 431 and 527.
† *Survey of India, Professional Paper No.* 9, 1905. *Annual Report of the Board of Scientific Advice for India.* 1905-06.
‡ *Vide* table v.

MAKALU.

A rock basin filled with glacier-ice is situated near the summit of Makalu and gives a striking appearance to the peak.

In 1853 before trigonometrical observations had been taken Captain Sherwill wrote of Makalu :—

" One mountain in the Nepal range is a most remarkable object, both for its curious shape and " for its immense height : its name none of my party knew, nor have I yet succeeded in obtaining the " name. The peak is a hollow crater-like mountain probably 27000 feet in height with a long table-" mountain attached to it, both covered with glaciers." *

In 1884 Colonel Tanner wrote : —

" With the exception of the Kinchinjunga peak, Makalu is the finest yet fixed in the eastern " Himalaya. It stands apart from the Everest group and exposes a great mass of snow towards the " Sandakphu ridge. From the south, in the plains of Bhagalpur and Purnea, it is the most striking " object in the panorama of snow. It has a remarkable cup or hollow, which extends for about one-" third down its slope, by which it may be recognised. When examined with a high-power telescope " great masses of glacier-ice may be seen finding their way over the edge of the cup. This ice has " been collected round the sides of the amphitheatre-like hollow. The upper half of the mountain is " composed of a very light coloured rock, but the southern spur is dark like the cliffs, which are seen " on the southern face of Everest. The white colour of the rock lends it a softness, which is absent " in the appearance of its higher neighbour. The southern and eastern faces are fully snow-clad, but " on the west are much bare rock and extensive streaks and patches which are too steep to retain " snow on their slopes. No northern spur of this mountain has been seen, but I have traced one " of about 19000 feet elevation towards the east, until it dips into the Arun valley. To the south two " picturesque branches fully clad with snow are thrown off, but I cannot say that I have detected " any saddle or ridge connecting Makalu with Everest."

Makalu is remarkable for its sharp-edged buttresses, one of which is a magnificent specimen of the spiral type. These spiral buttresses conveying the idea of torsion are to be seen in all parts of the Himalaya: Rakaposhi in Hunza has one, Simvo (22360 feet) in Sikkim has one, and to residents of Mussooree the curvature of the eastern buttress of Banog (7433 feet), a small peak in the vicinity, is a permanent object of beauty.

Hermann de Schlagintweit, when observing Makalu from Phallut in 1855, mistook it for Mount Everest, † and the same mistake has been made by other travellers. Sandakphu, situated 38 miles from Darjeeling and on the Singalila ridge, commands a fine view of Makalu: from there the peak is 78 miles distant and is a more striking feature than Mount Everest, which stands 12 miles in rear.

The outlines of Makalu and Everest as seen from Sandakphu are shown in chart VI.

PEAK T45.

T45 is a high peak of the Nepal Himalaya seventeen miles north-west of Mount Everest. It appears to have been missed by the observers of the Great Trigonometrical Survey in 1850, but was observed by Tanner in 1884 from three different stations. Tanner recorded that it had a rounded top.

* *Journal, Asiatic Society of Bengal,* Vol. XXII, 1853.

† *Vide Nature,* No. 1828, Vol. 71 ; Nov. 10, 1904 ; page 3.

NANGA PARBAT.   ●

Nanga Parbat is the most isolated and perhaps the most imposing of all the peaks of Asia. With the exception of subordinate pinnacles rising from its own buttresses, no peak within 60 miles of Nanga Parbat attains an altitude of more than 17000 feet. Throughout a circle of 120 miles diameter Nanga Parbat surpasses all other summits by more than 9000 feet. Its upper 5000 feet are precipitous.

"Perhaps in describing mountains," wrote John Ruskin in *Modern Painters*, "with any effort to give some idea of their sublime forms, no expression comes oftener "to the lips than the word 'peak,' and yet it is curious, how rarely even among the "grandest ranges an instance can be found of a mountain ascertainably peaked in the "true sense of the word,—pointed at the top and sloping steeply on all sides."

A traveller in the Himalaya, who has studied the writings of Ruskin, must constantly be impressed with the accuracy of his observations. How often do we see a high peak towering above us, only to find on ascending that it is but an obtuse angle in the slope of a buttress? How often is a needle discovered to be but the end of a sharp-edged ridge? Many of the peaks of tables I to VI, though they may form good definite points for surveyors, fail to satisfy Ruskin's definition.

But no one can question the claims of Nanga Parbat: its form and its solitude render it a "peak," however we define the word.

"Nanga Parbat's summit," wrote Colonel Tanner, "is 26620 feet above the sea, and its base "stands on the left side of the Indus valley, which at that point is but 3500 feet: it therefore exposes "23120 feet of its side to an observer, who, standing as near as he may dare to the edge of perhaps the "most lofty cliff in the world with the Indus valley 12000 feet below him, may regard at the distance of "less than 40 miles the unparalleled view presented by the vast snow fields, glaciers, and crags of this "King of Mountains. It is a scene that is not grasped or taken in at once, but after a while the "stupendous grandeur of the view is appreciated. It is quite overwhelming in its magnitude; it is "in fact one of the grandest spectacles that nature offers to the gaze of man."

Until the height of Nanga Parbat had been determined by the Great Trigonometrical Survey, it was given on maps as 19000 feet. An error amounting to 7600 feet in defect in the case of a solitary impressive peak shows how worthless are eye-estimations of height.*

MASHERBRUM OR K¹.

The Masherbrum peaks are two well-defined points connected by a saddle: they are 1000 feet apart and differ by 50 feet in altitude.

RAKAPOSHI.

Of Rakaposhi Colonel Tanner wrote as follows: "The mighty Rakaposhi or devil's "tail of Gilgit, rising from ground which is 7000 or 8000 feet above the "sea, may be viewed from a distance of less than 40 miles by any one bold enough to

" make the journey over the dreadful Saichar pass to Chaprot and thence up to the
" grassy downs above that place, and the splendid appearance of Rakaposhi will be a
" sufficient reward for his trouble. It is a vast clean-cut brilliant snow needle, abso-
" lutely sharp, rising thousands of feet above a mass of broken snows, below which are
" the wild precipices and serrated ridges peculiar to the Gilgit mountains."*

KAMET.

Kamet is a conspicuous landmark from all the elevated parts of Nari Khorsam;
it is also visible from Almora on the Indian side, " where, however, its appearance is
" so modest that, till 1849, it remained unnoticed and unmeasured, though but 250 feet
" lower than the King of the western Himalaya, Nanda Devi."†

Kamet stands behind the Great Himalaya range and its height was first de-
termined by Richard Strachey. Its outline as seen from Cheena is shown in chart VII.

TIRICH MIR.

Snow forms a thick unbroken covering over Tirich Mir, and gives to the peak a
rounded rather than a pointed top. The patches of naked rock, that are to be seen
on all the slopes of the great peaks of the Himalaya, are absent from the flanks of
Tirich Mir.

GURLA MANDHATA.

Dr. T. G. Longstaff made an attempt to climb Gurla Mandhata in 1905, and
attained a great height, possibly exceeding 23000 feet, but failed to reach the summit.‡

In 1878 Mr. Ryall wrote of this mountain as follows :—

" Gurla Mandhata, which is 3500 feet higher than Kailas, is held in comparatively
" little religious esteem among the Buddhists and Hindus. Owing to its immense
" bulk and height—3000 feet above any peak within a radius of 40 miles—it is perhaps
" the most impressive sight in the whole of the Himalaya, the celebrated mountain of
" Nanga Parbat alone excepted."§

KUNGUR AND MUZTAGH ATA.

The peaks of Kungur and Muztagh Ata have been mistaken for one another by many
travellers. Captain Trotter was the first trigonometrical observer of Kungur, and from
the plains of Kashgar he determined its height at 25350 feet; he named the peak
" Tagharma."

Muztagh Ata is 26 miles south of Kungur and is not visible from Kashgar. Travel-
lers have frequently thought that they have seen Muztagh Ata from Kashgar : but they
have been misled by the natives, who believe Kungur and Muztagh Ata to be one
summit. Colonel Wahab called the Muztagh Ata peak " Tagharma."

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* General Report, Survey of India, 1883-84.

† Journal, Royal Geographical Society, Vol. XXIII, 1853,—Captain H. Strachey On the Physical Geography of Western Tibet.

Henry Strachey wrote before the height of Nanga Parbat had been ascertained. Montgomerie was right when he said that Nanga Parbat was as much the King of the western Himalaya as Mount Everest was of the eastern. Nanga Devi is the highest point of the Kumaun or central section of the Himalaya, but does not compete with Nanga Parbat.

‡ Charles A. Sherring: Western Tibet and the British Borderland ; also Alpine Journal, August 1906.

§ General Report, Survey of India, 1877-78.

The fact that both Kungur and Muztagh Ata were named " Tagharma" by surveyors has tended to increase the confusion. The name Tagharma is given by natives to the peak of Muztagh Ata because it towers above the town of Tagharma in the Sarikol valley, and Wahab was correct in his application of the name. But Trotter made a mistake in adopting the assumption of Kashgarians, that the great snow peak they see to the south-west is the same peak as seen from Tagharma.

There has not only been a confusion of names, but differences of opinion have existed as to which of the two peaks is the higher, Kungur, the northern, or Muztagh Ata, the southern. The values of height entered in tables IV and V are those derived from the data at the disposal of the Survey of India, but it has to be acknowledged that the observations are less reliable than those of the Himalayan and Karakoram peaks. In the case of observations taken to peaks from stations in India the height of the place of observation is accurately known, but the same cannot be said of the points from which Kungur and Muztagh Ata were observed. Though all our information goes to show that Kungur is higher than Muztagh Ata, by about 758 feet, the great weight of Sven Hedin's authority is on the side of Muztagh Ata. " Muztagh Ata," he writes, " the loftiest mountain of the Pamirs and one of the " loftiest mountains in the world, towers up to the height of 25600 feet, and like a " mighty bastion overlooks the barren wastes of Central Asia. It is the culminating point " in a meridional chain. The unchallenged pre-eminence of Muztagh Ata over the peaks " which cluster around it is proved by its name, which means the Father of the Ice " Mountains."*

Sven Hedin made three attempts to climb Muztagh Ata, but was not successful.

Lord Curzon describing the peaks of Kungur and Muztagh Ata wrote : " The " second and southerly peak, which from Sarikol obscures the first, is the real " Muztagh Ata, the height of which is probably a little less than its nameless brother, " being calculated at about 25000 feet, but which is a far finer mountain since it is " conical and comparatively isolated, whereas the more northerly mountain is the " highest crest of an extended ridge."†

API AND NAMPA.

The remarkable group of peaks in western Nepal, of which Api and Nampa (table VI) are the principals, has been imperfectly studied. During the observations of the Great Trigonometrical Survey the cluster was continually obscured by haze, and only one peak was observed. A crowded cluster that is seldom visible in winter, except perhaps on certain days for a few minutes at sunrise, and that is completely hidden by clouds in summer, presents great difficulties to the observer.

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* Sven Hedin: *Through Asia*, page 221. It is perhaps unfair to give this quotation, for when Sven Hedin wrote he may have been unaware that there was any question at issue. As, however, his book has had a wide circulation, we think it right to point out that our results do not confirm Sven Hedin's opinions.

† *Geographical Journal*, Vol VIII, 1896.

If he succeeds in observing the directions of six peaks from both an eastern and a western station, each of the six rays from his eastern station cuts each of the six from his western, and thirty-six points of intersection are given within a small area. If the peaks have been observed from a third station also, difficulties disappear, but when they have been seen from two only, the true points of intersection have to be determined from a study of the several values of height.

Many map-makers have confused the peaks of Api and Nampa, but their heights differ by 1237 feet. Colonel Tanner's observations show that Api is a double peak, the higher point of which (23399 feet) stands half a mile north-east of the lower (23287 feet).

The observations of Colonel Tanner's assistant Rinzin show another peak called Ningru (23143 feet) rising between the two peaks of Api. It is extremely unlikely that the name of Ningru has been attached by natives to this close companion of Api, and it is more reasonable to assume that Api and Ningru are alternative names employed, perhaps in different localities, for the same snowy mass.

According to the observations of Tanner's assistants Nampa is a double peak also, the two summits being 2 miles apart. The higher Nampa is 4 miles east of the higher Api.

The only peak of this cluster observed by the Great Trigonometrical Survey was peak LIII : its position was fixed, but not its height; its position, which was determined from two stations of observation only, is 1½ miles south-south-west of Api (23399 feet).

The *Encyclopædia Britannica* shows a peak of this cluster as Mount Humla (24702 feet), but, incomplete as the trigonometrical observations of the Api-Nampa group have been, they are sufficient to indicate that no peak exceeding 24000 feet stands in this region.

The outline of Api is shown in chart VII.

" The purity of its unbroken snow and boldness of its outline," wrote Colonel Tanner of the Api peak (23399 feet), "I have nowhere seen equalled. The ridges that connect the highest with the " lower points of Api are perfectly sharp and decided, and for several thousands of feet there is scarcely " a splinter of naked rock to mar the unrivalled whiteness of its slopes. The base and lower spurs of " Api touch the Kali valley and are clothed with variegated masses of birch and pine except in those " places where constantly recurring avalanches admit only of the growth of short grass." *

CHUMALHARI.

The peaks of Chola (17310 feet) and of Chumalhari (23930 feet) appear from Senchal near Darjeeling to be in almost the same direction, the distance of Chumalhari being double that of Chola.†

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* *General Report, Survey of India*, 1884-85.
† Chola is called Chumunko in table VI and Gaoring on North-Eastern Trans-Frontier Sheet No. 7 N. W.

A letter written by Dr. Campbell from Darjeeling in 1848 is interesting as showing how mistaken the natives of the mountains may be. His letter runs :—

"When Colonel Waugh left this place in November last, after having satisfied himself of the "position of Chumalhari by observations from Tonglu and Senchal, I took some Lepchas and "Bhotiahs, who had travelled into Tibet by the Phari route, with me to the top of Senchal, to "point out Chumalhari to them, as they were positive in stating their belief that it was not visible from "any part of this neighbourhood. When I said 'There is Chumalhari,' the whole party exclaimed "'No, it is Chola, and not Chumalhari.' I took pains to ascertain the reasons of their dissent, "and afterwards wrote an epitome to Colonel Waugh, who said, as far as I recollect, 'You may rely "upon it, that I shall not finally decide the point until you are satisfied that I am right.' "*

Colonel Waugh eventually proved that the peak observed from Senchal was Chumalhari.

KAILAS.

"It is solely due," wrote Mr. E. C. Ryall, "to the circumstance of its shape resem- "bling that of a Hindu temple that Kailas is vested with a sacred character."†

SER AND MER.

Ser and Mer, known also as the Nun Kun peaks, are remarkable twin giants (*vide* table VI), rising from a region of perpetual snow : they are the highest points of the Punjab Himalaya between the Sutlej and Nanga Parbat. Ser is white and Mer is dark, being too precipitous on the side of India to retain much snow.

Ser is 2½ miles south-west of Mer : a third peak (22810 feet) stands 1¾ miles east-north-east of Mer, and there is a fourth peak (22310 feet) two miles east of Mer. The positions and heights of these four peaks were well determined. The account given in the *Geographical Journal* ‡ of the Bullock-Workman expedition refers to a third peak of the group, exceeding 23000 feet. No third peak however of 23000 feet was observed by the Trigonometrical Survey. The peak climbed by Mrs. Bullock-Workman was Mer.

TENGRI KHAN.

Tengri Khan is the highest peak of the Tian Shan and the highest point of Asia north of latitude 39°. In his *Central Tian–Shan Mountains* Merzbacher describes the isolated eminence of Tengri Khan as "without example in mountain systems of like extent." "The mountain," he says, "has no rival and overtops the highest "summits of all the neighbouring ranges by over 3000 feet."

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* *Journal, Asiatic Society of Bengal*, Vol. XVII.
† *General Report, Survey of India*, 1877-78.
‡ November, 1900.

3

ON THE NAMES OF CERTAIN PEAKS.

It is not often that a surveyor can discover a native name for a peak : natives of the hills do not give names even to remarkable peaks.

Absence of Native names. "To my disappointment," wrote Sir Joseph Hooker, " I " found that neither priest nor people knew the name of a single snowy mountain." *

Of the 75 great peaks included in tables i to v but 19 have native names. If we take into account the lower peaks, we find that there are many thousands of prominent but unnamed summits in Asia, and the problem of nomenclature has to be considered. It would be a mistake to attempt to attach an actual name to every peak. Astronomers do not name the stars : in olden times they grouped them in constellations, and they now number them according to right ascension. Colonel Montgomerie endeavoured to introduce for peaks a method resembling that of constellations, and he named the whole Karakoram region K, and its peaks K^1, K^2, K^3, etc.†

This system would have answered well, but Colonel Tanner and subsequent surveyors have departed from it, and have adopted the plan of designating each peak by the initial letter of the observer : Tanner called, for instance, the peaks he had observed himself T^{45}, T^{57}, etc. The employment of observer's initials has led to confusion ; two and more observers have had the same initial, and the same symbol has thus become attached to different peaks. Moreover the designations given under Tanner's system furnish no clue as to the region in which the peaks are situated.

The nomenclature of a mountain region should not be forced : it should grow spontaneously, and we should never invent a name until its absence has become inconvenient. We cannot do better for Tibet and Turkistan than extend the simple system introduced by Montgomerie for the Karakoram : his method of constellations is more suitable for the peaks of Asia than a long series of successive numbers from west to east would be. We need not design constellations to include one whole range, and we need not follow the astronomical plan of drawing animals and heroes; we can have rectangular constellations enclosed by meridians and parallels.

Peaks however possess in their heights an attribute which stars lack, and there is no more useful means of distinguishing peaks than by

Peaks can be distinguished by their heights. their heights. If we are dealing with a complex cluster of peaks, it is simpler to indicate the several members by their heights than to confer on them separate names. In discussions of the peaks of Asia heights must be accepted to a certain extent as substitutes for names.

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* *Himalayan Journals*, Vol. 1, page 370.

† A note on the name Karakoram is given in Section 16 of Part II of this paper.

There will be no difficulty in preventing the same value of height being given to two or more peaks. The heights of peaks are not known within 10 feet, and it is thus possible to adjust the height of a newly measured peak by one or two feet, if it happens to have been given the same height as one previously determined.

If the heights of peaks come to be recognised as a means of identification, they should not be altered whenever any trifling improvement in the value is believed possible. The height of Mount Everest was originally determined at 29002 feet, and this value should still be retained : a few years ago its height on maps was reduced to 28995 feet because the stations from which it had been observed were found to be 7 feet lower than had originally been assumed: subsequently for a similar reason the height was altered to 28994 feet. But these alterations were not justifiable, and only tended to produce confusion. It is known that the height 29002 feet is, if anything, too low, but it is not desirable to alter it, because the value 29002 is a clear indication of the particular peak denoted.

We are not proposing now to bind our successors for all time to adhere to the present values of heights : periodical revisions of values can be carried out every twenty or fifty years, if fresh information has been accumulated in the interim. All that is proposed now is that the heights allotted to the peaks in tables I to VI be accepted until proof is forthcoming of serious error, and that no small or frequent changes in value, such as have constantly led to confusion in the past, be made in the future.

In the following table are shown the various names and symbols that have been applied to the several peaks of tables I to VI at different times by surveyors and travellers :—

TABLE VII.—Names and Symbols which have been used by different authorities to denote the peaks of tables I to VI.

No. of Peak.	Name adopted in this paper.	Name employed in the records of the Great Trigonometrical Survey.	Names employed by observers in the field.	Alternative names occasionally used.
1	Mount Everest	XV	.	See below.
2	K²	Karakuram No. 13* .	K² *by Montgomerie*	Mount Godwin-Austen (see below), Dapsang *by Schlagintweit in* 1856.
3	Kinchinjunga I	IX		..
4	Kinchinjunga II	VIII		..
5	Makalu	XIII		..
6	T⁴⁵		T⁴⁵ or T45 *by Tanner*	..
7	Dhaulagiri	XLII		..
8	XXX	XXX		..
9	Nanga Parbat I	Nanga Parbat		Dayamur, Dairmal, Deo Mir.
10	XXXIX	XXXIX		..

* The name *Karakoram* was spelt *Karakuram* by Montgomerie, and is consequently so spelt in many of the records of the Great Trigonometrical Survey. But the form *Karakoram* is now held to be correct.

TABLE VII.—Names and Symbols which have been used by different authorities to denote the peaks of tables I to VI—*continued*.

No. of Peak.	Name adopted in this paper.	Name employed in the records of the Great Trigonometrical Survey.	Names employed by observers in the field.	Alternative names occasionally used.
11	K^5 or Gasherbrum I	Karakuram No. 9	K^5	..
12	K^4 or Gasherbrum II	Karakuram No. 10 (Gusherbrum)	K^4	..
13	Gosainthan	XXIII		..
14	K^{3a} or Gasherbrum III	Karakuram No. 11	K^{3a}	..
15	XXXIV	XXXIV		..
16	K^3 or Gasherbrum IV	Karakuram No. 12	K^3	..
17	T^{57}		T^{57} *by Tanner*	..
18	B^{782}		B^{782} *by Barckley*	Fishback *by Tanner*
19	XXVIII	XXVIII		..
20	Kambachen		North of Kanchin *by Robert,* S. E.13 *by Tanner*	..
21	XXIX	XXIX		..
22	Masherbrum East	Masherbrum E.	K^1 East	..
23	Nanda Devi	LVIII		A No. 2 *by Hodgson and Herbert* : XIV *by Webb*
24	Masherbrum West	Masherbrum W.	K^1 West	..
25	Nanga Parbat II		Great Range No. 30	..
26	LIX	LIX		..
27	Rakaposhi	Rakipushi	U^{40}	..
28	Kunjut No. 1	Kunjut No. 1.	Trans-Indus No. 4	..
29	Kamet	LXVII	Kamet *by Richard Strachey,* Kangmen *by Ryder*	Ibi Gamin *by Schlagintweit*
30	T^{42}		T^{42} *by Tanner*	..
31	XLIII	XLIII		..
32	Tirich Mir I		DsEb *by Tanner*	..
33	N^{53}		N^{53} *by Robert*	..
34	K^{10}	Karakuram No. 3	K^{10}	..
35	Hunza-Kunji I	Kunji No. 8	T^{95} *by Tanner*	..
36	Gurla Mandhata		Memonamnyimri *by Ryder*	Nimo Namling *by Tanner*
37	Jano	XI		Jannu
38	K^{11}	Karakuram No. 4	K^{11}	..
39	XLIV	XLIV		..
40	B^{753}		B^{753} *by Barckley*	..
41	Shyok Nubra Watershed No. 5.	Sheok-Nubra Watershed No. 5.	K^{22}	..
42	Kungur I		Peak 2 of Camp 9 *by Ram Singh*	Tagharma *by Trotter,* Mount Dufferin *by Ney Elias*
43	B^{504}		B^{504} *by Barckley*	..
44	Hunza-Kunji II		Highest Peak South *by Holdich*	..
45	Karakoram No. 8	Karakuram No. 8	K^6	Chogolisa *by Norman Collie*

TABLE VII.—Names and Symbols which have been used by different authorities to denote the peaks of tables I to VI—*continued.*

No. of Peak.	Name adopted in this paper.	Name employed in the records of the Great Trigonometrical Survey.	Names employed by observers in the field.	Alternative names occasionally used.
46	XLVI	XLVI		..
47	Hunza-Kunji III	Hunza No. 2	U^{51}	..
48	Kungur II		Peak 3 of Camp 9 *by Ram Singh*	..
49	XLV	XLV		..
50	XXXVI	XXXVI		..
51	Kulha Kangri I	Bhutan-Tibet range No. 2 Pk		..
52	Karakoram No. 5	Karakuram No. 5	K^{32}	..
53	XXXV	XXXV		..
54	Kulha Kangri II	Bhutan-Tibet range No. 1 Pk		R^{262} *by Ryder*
55	Shyok Nubra Watershed No. 3	Sheok-Nubra Watershed No. 3	K^{24}	..
56	Tirich Mir II		IGmi *by Tanner*	Nushau No. 1
57	Shyok Nubra Watershed No. 4	Sheok-Nubra Watershed No. 4	K^{23}	..
58	Kunjut No. 2	Kunjut No. 2	Trans-Indus No. 2 *by Montgomerie*	..
59	R^{264}		R^{264} or R264 *by Ryder*	..
60	Indus-Nagar Watershed No. 2	Indus-Nagar Watershed No. 2	U^{57}	..
61	LVII	LVII		..
62	Muztagh Ata		Tagharma *by Wahab*	..
63	K^{12}	Karakuram No. 4	K^{12}	..
64	A satellite of Kinchinjunga		Centre of great broad peak	..
65	Tirich Mir III		IGmf *by Tanner*	•••
66	Kuen Lun No. 1		Peak 9, Camp 58 *by Ram Singh*	•••
67	XXVI	XXVI	•	•••
68	Haramosh	Haramosh	B^{14} U^{69}	•.•
69	Sad Ishtragh		Dsb	..
70	XLVIII	XLVIII		•••
71	Kunjut No. 3	Kunjut No. 3	T^{97} *by Tanner*	•••
72	A satellite of Kinchinjunga		Centre of huge mass, North of Kinchinjunga	..
73	Hunza-Kunji IV		CBu	Boyohaghurdonas
74	Chamlang	XIV		..
75	Kabru	X		Ningru
76	Api			Ningru
77	Badrinath	LXIX	VIII *by Webb*	..
78	Bandarpunch	LXXVII		Jumnootri *by Gerard*
79	Chumalhari	1		..
80	Chumunko	IV		Chola *by Dr. Campbell*
81	Dayabhang	XXV		L or Dayabang *by Col. Crawford*

TABLE VII.—Names and Symbols which have been used by different authorities to denote the peaks of tables I to VI—*concluded.*

No. of Peak.	Name adopted in this paper.	Name employed in the records of the Great Trigonometrical Survey.	Names employed by observers in the field.	Alternative names occasionally used.
82	Deotibba	Deotibba		..
83	Dubunni	Dubunni		..
84	Dunagiri		a^{20} *by Carter*	..
85	Gangotri		Gangotri α S. P. *by Ryall*	..
86	Gardhar	Gardhar		..
87	Gaurisankar	XX		..
88	Jaonli	LXXV		..
89	Jibjibia East	XXII		..
90	Jibjibia West	XXIV		..
91	Kailas	Kailas		Kangrinpoche
92	Kaufmann			..
93	Kedarnath	LXXII	III *by Webb*	Bharti Khunta
94	Kharchakund		Kharcha Koond No. 2 S.P. *by Ryall*	..
95	Leo Pargial N.	Leo Pargial N.		..
96	Leo Pargial S.	Leo Pargial S.		...
97	Lunkho		IGmp	..
98	Mer	Mer or Kana		Kana. Kun. Dam Huy. The Nun Kun peaks are Mer and Ser
99	Nampa			Namju
100	Nandakna	LXIV		..
101	Nandakot	LVI		..
102	Narsing	VI		..
103	Nilakanta	LXVIII	IX (Nilakanta) *by Webb*	..
104	Panch Chulhi	LIV	XX *by Webb*	..
105	Pandim	VII		..
106	Pauhunri	III	Powhunri	Donkia *by Dr. Hooker*
107	Sargaroin	LXXIX	H. Left Peak *by Hodgson and Herbert*	..
108	Ser	Ser or Nana		Nana. Nun. Pajah Huy. The Nun Kun peaks are Mer and Ser
109	Simvo		S 30	..
110	Srikanta	LXXVI	Bus peak *by Du Vernet,* G or Srikanta *by Hodgson and Herbert*	..
111	Tengri Khan			..
112	Tharlasagar	LXXIV	M or Mont Moira *by Hodgson and Herbert,* I *by Webb*	..
113	Trisul East	LX	XIII (East Trisool) *by Webb*	..
114	Trisul West	LXII	A No. I *by Hodgson and Herbert,* XII (West Trisool) *by Webb*	..

In 1852 the chief computer of the Trigonometrical Survey informed the Superin-
tendent, Sir Andrew Waugh, that a peak designated XV
had been found from the computations to be higher than
any other hitherto measured in the world. This peak was discovered by the computers
to have been observed from six different stations: on no occasion had the observer
suspected that he was viewing through his telescope the highest point of the earth.*

The name of Mount Everest.

The Indian Survey had always adhered to the rule of assigning to every geo-
graphical feature its true local or native name, but here was a mountain, the highest
in the world, without any local or native name that the surveyors were able to
discover. The Surveyor General, Sir Andrew Waugh, decided to name the great
snow-peak "Mont Everest" after his former chief, Sir George Everest, the celebrated
geodesist.

Waugh wished to introduce the word "Mont" in preference to "Mount, " but
"Mont" never came into vogue. It seems to have been immediately replaced in
common usage by "Mount, " and for 50 years "Mount Everest" has been the name
generally adopted throughout the world.

When Sir Andrew Waugh announced that the peak was to be named "Mont
Everest," Mr. Hodgson, who had been political officer in Nepal, wrote many papers to
show that Waugh had been mistaken, and that the mountain had a local name, viz.,
Devadhunga. But Mr. Hodgson mistook another peak for Mount Everest and it is
probable that he never saw Mount Everest at all. All subsequent and recent infor-
mation goes to show that there is no peak of the Himalaya called Devadhunga.†

In 1855 Hermann de Schlagintweit visited a hill in Nepal called Kaulia near
Katmandu, and from it took observations to the snow peaks. He saw the mountain
called Devadhunga by Hodgson, and he identified it as Mount Everest; he however
repudiated Hodgson's name of Devadhunga and certified that the local native name for
the peak was Gaurisankar. Many geographers accepting Schlagintweit's views have con-
tinued to this day to call the highest mountain in the world Gaurisankar: the Indian
Survey however were unable to reconcile Schlagintweit's results with their own and
declined to follow him. There is no doubt now that Schlagintweit was misled in his
identification of Mount Everest. In 1903 Captain Wood, R.E., visited Kaulia by order
of Lord Curzon : he found that Gaurisankar and Mount Everest were different peaks
36 miles apart, and that the peak called Devadhunga by Hodgson and Gaurisankar
by Schlagintweit was a peak long known in the records of the Survey as peak XX
(height 23440 feet).‡

In addition to his Kaulia observations, Schlagintweit observed at Phallut on the
Singalila ridge, and from there he painted his now well-known picture of Mount

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* *Nature*, Nos. 1828 and 1830, Vol. 71 ; Nov. 10 and 24, 1904.

† This name may possibly be a mythological term applied to the whole snowy range by the natives of a
certain part of Nepal.

‡ See Wood's *Report on the Identification and Nomenclature of the Himalayan peaks as seen from Katmandu,*
·1904; also his *Narrative Report,* 1903-04.

Everest: but unfortunately he fell again into error, for the mountain he painted is clearly Makalu and not Mount Everest.

Of recent years endeavours have been made to show that the Tibetans have a name for Mount Everest, namely, Jomokangkar or Jhomogangar or Chamokankar, but no reliable evidence has been produced. In 1904 the surveyors attached to the Tibet Frontier Mission made careful enquiries, but found no such name applied to the great Himalayan peak. On the other hand the explorer Kishen Singh found a mountain called Jhomogangar * in the interior of Tibet, 215 miles north-east of Mount Everest. This peak of Jhomogangar has been shown on maps of Tibet since 1872. Kishen Singh in his narrative describes his arrival at Dung Chaka (15700 feet) and then adds, " About 10 miles to the east there is a lofty snowy peak called Jhomogangar, some- " what of the same shape as the Kailas peak near Manasarowur: it is a noted object of " worship, being considered as a female divinity."

After 50 years of controversy no true native name has been produced for Mount Everest: each of those suggested has in turn been shown to be inapplicable, and the evidence that no such name exists is overwhelming. In the meantime the name Mount Everest has been widely adopted, and it would be a mistake to go back upon it now. Personal names for geographical features are doubtless objectionable, but we must accept accomplished facts: geographical progress is retarded by unprofitable changes and by barren controversies over names.†

No native name for peak K² could be discovered by surveyors, and in 1856 it was designated K² by Montgomerie. The designation has been generally accepted, and will now, it is hoped, be retained in perpetuity.

The name of K².

When the final results of the Kashmir Survey were being prepared for publication, the numbering of the peaks of the Karakoram range was altered in order to produce continuity from west to east, and in some publications of the Great Trigonometrical Survey the peak K² is shown as Karakoram No. 13. This duplication of designations is now regretted, and the symbol K² will alone be used in future.

The height first given by the Survey to K² was 28278 feet; the value now accepted is 28250 feet.

Schlagintweit thought that the native name of peak K² was Dapsang: Sir Martin Conway gave it as Chiring :‡ and other travellers have reported it to be Chogo Ri.§

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* Latitude 29°50′ N.; Longitude 89°50′ E. *Geographical Journal*, Volume XXV, p. 179.

† In connection with the subject of personal names Lieutenant Wood, R.N., is often quoted as having given the name of Victoria to the Lake of Sir-i-Kul in the Pamirs; it may therefore not be out of place to quote Wood's own words : "As I had the good fortune to be the first European who in later times had succeeded in " reaching the sources of this river, and as, shortly before setting out on my journey, we had received the news of " her gracious Majesty's accession to the throne, I was tempted to apply the name of Victoria to this, if I may so " term it, newly re-discovered lake ; but on considering that by thus introducing a new name, however honoured, " into our maps a great confusion in Geography might arise I deemed it better to retain the name of Sir-i-Kul, the " appellation given to it by our guides."

‡ *Proceedings, Royal Geographical Society*, Vol. XIV, p. 857, and *Geographical Journal*, Vol. I, p. 177.

§ Ri merely means " mountain."

None of these names is in common use by the natives, and nothing would be gained by the adoption of any one of them.

Sir M. Conway writes of the Chogo peak as being quite distinct from K², and Dr. Hunter Workman attaches the name of Chogo Ri on his map to a different peak from K². Professor Norman Collie gives the name Chogolisa to peak No. 45 of table IV.

In 1888 at a meeting of the Royal Geographical Society it was proposed by General Walker to give the name of Godwin-Austen to peak K² after the officer who first surveyed the Karakoram range and glaciers; the name Godwin-Austen is now applied to the peak by many map-makers, but it has not been accepted by the Surveyor General of India and has not been entered on the maps of the Government of India.

Of all the designations suggested for the supreme peak of the Karakoram that of K² has now the widest vogue, and it will be in the interests of uniformity, if this symbol be adopted henceforth to the exclusion of all others. The permanent adoption of the symbol K² will serve to record the interesting facts that a mountain exceeding 28000 feet in height had not been deemed worthy of a name, by the people living under its shadow, and that its pre-eminent altitude was unsuspected until it was brought to light by trigonometrical observations.

The name Kinchinjunga has been spelt in a variety of ways. Uniformity in spelling is of more importance to geographers than correct-

The name of Kinchinjunga.

ness. The correct forms are doubtless Kanchenjunga or Kanchendzonga, but the more familiar form of Kinchinjunga is that adopted by the new Imperial Gazetteer, and this, it is to be hoped, will now come into general use. In north-eastern Nepal Kinchinjunga is known as Kumbhkaran Langur.

The name of Leo Pargial has figured too long upon maps to be abandoned now,

Leo Pargial.

but the natives on both sides of the Bashahr-Tibet border call the peak Rio Pórgyúl. Rio is merely a different form of the word Ri, meaning mountain, as in Chumalhari.

4

ON THE ERRORS OF THE ADOPTED VALUES OF HEIGHT

The values of height given in tables I to VI of this paper must be accepted with caution; some are more reliable than others, but none are correct to a foot, and many investigations will have to be completed before altitudes can be determined with a greater degree of accuracy than at present.

All observations are liable to error; no telescope is perfect, no level is entirely **Errors of observation.** trustworthy, no instrumental graduations are exact, and no observer is infallible.

In ordinary triangulation the objects to be observed are sharp and specially erected signals, but for the observations of a high peak, the summit, however ill-defined, cannot be furnished with a suitable mark.

If a flat-topped peak be observed from a near station, the surveyor runs the risk of mistaking some lower point for the summit, the latter being obscured from his view by an intervening shoulder.

Errors of measurement however can be greatly reduced and rendered practically negligible, if a peak be observed with a good theodolite on *several* occasions and from *different* stations; observations of Mount Everest, of K^2, of Kinchinjunga, and of others have been repeated so often and from so many different places that the local angles of elevation have been probably determined within one or two seconds of the truth and the errors in the mean values of height *due to faults of observation* are probably less than 10 feet. But in the cases of peaks Nos. 18 and 30 of table IV, and others, which have been observed from one station only and on but few occasions from that, errors due to faults of observation may attain to 100 feet. A single intersection of a peak from a single station deserves no weight whatever: it may give a result hundreds of feet in error.

Heights in the Himalaya that have been measured from one or two stations only **The adoption of an erroneous height for the observing station.** may in places be thrown into error to the extent of 10 or 15 feet by the adoption of erroneous altitudes for the stations of observation.

In the case of the Karakoram and Ladak ranges the liability to error on this account is larger and is perhaps 30 feet: the peaks of the Hindu Kush have been observed from less known stations than those of the Karakoram and are possibly 70 feet in error in consequence.

The Kashgar range being still more remote from the triangulation of India, the heights of its peaks are less reliable than those of the Hindu Kush; and the peaks of Kungur and Muztagh Ata may be in error by 300 feet, or even more, on account of the accumulation of error in the assumed altitudes of the stations from which they have been observed.

An element of uncertainty is introduced into heights by the fact that the altitudes

Variations of snow.

of peaks are always varying in nature with the increase and decrease of snow. The discrepancies that obtain between the different determinations of height of the same peak may be partly due to the fact that some observations have been made after the snow has been accumulating, and others after it has been diminished by heat, evaporation, wind, and avalanches. All heights on land have to be measured from the surface of the sea, and as the latter rises and falls with the tides, a mean level of the sea has to be adopted; and so in the case of the great peaks, we shall have eventually to assume the mean level of the snow at their summits as the altitude to be determined.

A plumb-line is a string supported at its upper end and stretched by a weight

The deviation of gravity from the normal.

attached to its lower end.* If there were no irregularities of matter near the earth's surface a plumb-line would hang truly normal; but mountains exert a lateral pull, and tend to deflect it towards them. In the same way as plumb-lines are pulled out of the normal, so is the surface of water near mountains pulled out of its spheroidal form. The attraction of the great mass of the Himalaya and Tibet pulls all liquids towards itself, as the moon attracts the ocean, and the surface of water in repose assumes an irregular form at the foot of the Himalaya. If the ocean were to overflow northern India its surface would be deformed by Himalayan attraction. The liquid in levels is similarly affected and theodolites cannot consequently be adjusted: their plates when levelled are still tilted upwards towards the mountains, and angles of elevation as measured are too small by the amount the horizon is inclined to the tangential plane. At Darjeeling the surface of water in repose is inclined about 35″ to this plane, at Kurseong about 51″, at Siliguri about 23″, at Dehra Dun and Mussooree about 37″.

No attempt has yet been made to apply corrections to the values of heights on account of Himalayan attraction: the determinations of the deflections of the plumb-

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* To render intelligible references to the deviation of gravity it is necessary to define the following words, *vertical, horizontal, normal, level, tangential.* If the earth had been at rest, it would under the influence of gravity have assumed the form of a sphere: its rotation round an axis has converted the sphere into a spheroid flattened at the poles. The present figure of the earth is not a perfect spheroid, however, as the surface is disfigured by mountains and valleys, which are rigid enough to withstand the influences of gravity and rotation. Everywhere in fact on land we meet with slopes and cliffs that are obviously inclined to the general surface of the earth. Water, however, whether it be in a basin, or lake or ocean, conforms closely to the spheroidal surface, and it is more exact to say that the figure of the sea is a spheroid, than that the figure of the earth is one. The surface of the sea, however, though more nearly spheroidal than that of the land, suffers from slight irregularities, and water in repose does not conform exactly to the spheroid. Continents and mountains attract water towards themselves, and their attraction disfigures the surfaces of oceans and ponds and levels. If the earth were a homogeneous and perfect spheroid, the direction of gravity would everywhere be perpendicular to its surface, but the earth is irregular, and gravity does not always coincide with the perpendicular to the general surface. Gravity acts in a direction perpendicular to the surface of water. We have then to consider what we mean by a *vertical* line— whether it is the perpendicular to the earth's mean surface or whether it is the direction of gravity. The word *vertical*, we think, should be employed to describe the direction of gravity; the line perpendicular to the mean surface should be called the *normal.* The actual surface of the sea and of water, however disfigured from a spheroid, is the *level* surface, and the word *level* should only be applied to this actual surface. The following definitions will explain the difference between the *horizontal* and *tangential* planes at any point of the earth's surface: the *horizontal* is the plane that is tangential to the local surface of water, however the latter may be deformed: the *tangential* plane is the plane that is tangential to the mean spheroidal surface.

line are at present not sufficiently perfect to justify the results being utilised to correct altitudes.*

We know that all angles of elevation to Himalayan peaks measured from the plains of India and from the outer hills are too small, and consequently all our values of Himalayan heights are too small. Errors of this nature range from 40 to 100 feet.

Of the deflection of gravity from the normal in Tibet or Kashgar or on the Karakoram or Hindu Kush we know as yet nothing.

If a peak be observed from different directions, the deflection of the plumb-line in the plane of the peak will probably be different at every observing station, and the several values of height may consequently appear discordant. Such discordances, however, are unavoidable; their presence implies that the direction of gravity has been varying, and it leads us to hope that the errors due to deflections of the plumb-line are tending to cancel in the mean.

The most serious source of uncertainty affecting values of heights is the **Atmospheric Refraction.** refraction of the atmosphere. A ray of light from a peak to an observer's eye does not travel along a straight line, but assumes a curved path concave to the earth. The ray enters the observer's eye in a direction tangential to the curve at that point, and this is the direction in which the observer sees the peak. It makes the peak appear too high. Refraction is greatest in the morning and evening and least in the middle of the day: it is different in summer from what it is in winter. If we observe Dhaulagiri from the plains of Gorakhpur, it appears to fall 500 feet between sunrise and the afternoon, and to rise again 300 feet before sunset. Even in the afternoon, when it appears lowest, it will still be too high by perhaps 700 feet.

In 1853 Sir Andrew Waugh determined the curvature of the path of a ray of light between the outer Himalaya and the low plains of Bengal by means of simultaneous observations taken from both ends of the ray. He then assumed that the path of a ray to a snow peak would be similarly curved, and he reduced the apparent heights of the peaks accordingly. But we believe now that he reduced the heights by too much: his determination of a ray's curvature in the outer Himalaya was correct, but this curvature, we think, is not maintained at higher altitudes. As the rarefaction of the atmosphere increases, the ray assumes a less curved path, and Sir Andrew Waugh's method attributed to refraction a greater effect than it really has. To the Karakoram heights Colonel Montgomerie employed smaller corrections for refraction than Waugh used for the Himalaya.

Philosophical Transactions of the Royal Society of London: Series A. Volume **205** (1905), pp. 289 to 318.

E

If we bring together in the following table the different errors to which carefully

Summary of errors. determined heights of peaks are liable it will help to focus our ideas: —

TABLE VIII.—Magnitudes of possible errors.

Source of error.	Great Himalaya range.	Karakoram range.	Kashgar range.
Variations of snow-level from the mean . .	Unknown. . .	Unknown .	Unknown.
Errors of observation	10 feet . .	20 feet .	100 feet.
Adoption of erroneous height for observing station	10 feet . .	30 feet .	300 feet.
Deviation of gravity	60 feet, too small .	Unknown .	Unknown.
Atmospheric refraction	150 feet, too small .	10 to 30 feet	50 feet.

The following table shows how the different values of the height of Mount Everest

Deduction of the height of have been deduced:—
Mount Everest.

TABLE IX.—Height of Mount Everest.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Mount Everest.	Value of height, if no correction for refraction be applied.	Resulting height as determined by Waugh with co-efficients of refraction varying from 0·07 to 0·08 from stations in the plains.	Resulting height from computations in 1905 with co-efficient of refraction 0·05 from stations in the hills.	Resulting height with assumed co-efficient of refraction 0·0645 from stations in the plains.
		Feet.	Miles.	Feet.	Feet.	Feet.	Feet.
Jirol	1849	220	118·661	30366	28991·6	..	29141
Mirzapur	1849	245	108·876	30165	29005·3	..	29135
Janjpati	1849	255	108·362	30141	29001·8	..	29117
Ladnia	1849	235	108·861	30171	28998·6	..	29144
Harpur	1849	219	111·523	30221	29026·1	..	29146
Minai	1850	228	113·761	30282	28990·4	..	29160
Suberkum	1881	11641	87·636	29576	..	29141	..
Do. . . .	1883	11641	87·636	29572	..	29137	..
Tiger Hill	1880	8507	107·952	29860	..	29140	..
Sandakphu	1883	11929	89·666	29620	..	29142	..
Phallut	1902	11816	85·553	29589	..	29151	..
Senchal	1902	8599	108·703	29941	..	29134	..
Mean	..	..	..	..	29002	29141	29141
Range of variation in values* .	..	..	..	794	Misleading.†	17	43

The 5th column gives the values of height obtained from observation, if no correction for refraction be applied. It will be noticed that all the values of height in this column derived from observations taken at low-lying stations exceed 30000 feet, whereas those derived from observations taken at high altitudes are less than 30000 feet.

The reason of this difference is that refraction tends to elevate a peak to a greater extent when the observation is made through the thick atmosphere of the plains than

* The range of variation is the difference between the largest and smallest values of height in the column above ; it is the maximum discordance obtained, and as such it furnishes evidence as to the correctness of the refraction co-efficient adopted.

† The extent of the range of variation affords no useful information unless the same value for refraction has been employed throughout. By using selected values of refraction we can make all values of height identical and have no range of variation at all.

when the line of sight passes only through the rarefied air of hill stations. It will be noticed that when no correction for refraction is applied, the largest of the values in the 5th column differs from the smallest by 794 feet, but that the application of corrections reduces the discrepancies materially.

The height 29141 is still probably too small, as it has yet to be corrected for the effects of deviations of gravity. Though it is a more reliable result than 29002, the latter value is still to be retained in maps and publications of the Survey. We cannot claim to have solved the problems of refraction, nor to have eliminated all uncertainties: our knowledge of the deflections of gravity is still but superficial, and although we may endeavour continually to improve our heights, it would be a mistaken policy to introduce new values at every step of the investigation. Values of heights, as has been explained in a previous section, furnish means of identification and are not to be altered frequently or without good reason. We have discussed the height of Mount Everest to show the degree of uncertainty attaching to it, but we do not propose to substitute 29141 for the long adopted and well-known value 29002.*

Deduction of the height of Kinchinjunga. It is probable that the accepted height of Kinchinjunga is, like that of Mount Everest, too small: the following table shows how the height of Kinchinjunga has been deduced :—

TABLE X.—Height of Kinchinjunga.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Kinchinjunga.	Values of height, if no correction for refraction be applied.	Resulting height as determined by Waugh with co-efficients of refraction varying from 0·07 to 0·09 from stations in the plains.	Resulting height from computations in 1905 with co-efficient of refraction 0·05 from stations in the hills.	Resulting height with assumed co-efficient of refraction 0·0645 from stations in the plains.
		Feet.	Miles.	Feet.	Feet.	Feet.	Feet
Dumdangi	1847	307	84·951	28856	28137·8	..	28224
Thakurganj . . .	1847	264	88·491	28948	28138·3	..	28266
Bandarjula . . .	1847	238	92·560	29060	28128·6	..	28312
Minai	1850	228	115·174	29494	28162·5	..	28346
Baisi	1850	234	115·031	29483	28152·1	..	28322
Harpur	1849	219	124·694	29651	28133·7	..	28297
Senchal . . .	1847	8599	50·158	28401	28138·8	28231	..
Birch Hill . . .	1847	6874	44·907	28379	28152·3	28239	..
Tonglu . . .	1847	10073	46·369	28370	28169·6	28220	..
Observatory Hill . .	1884	7162	45·720	28353	..	28212	..
Mean	..	..	..	..	28146	28226	28295
Range of variation in values †	..	..	..	1298	Misleading.‡	14	122

If we examine the results of the 5th column, which have not been corrected for refraction, we find that all the heights derived from observations at low-lying stations exceed 28800 feet, and all those derived from observations made at high altitudes are below 28410. The heavy atmosphere of the plains had greater refracting effects than the rarefied air of the hills and raised the peak to a greater extent.

* *Survey of India, Professional paper No. 9, 1905.*

† The range of variation is the difference between the largest and smallest values of height in the column above ; it is the maximum discordance obtained and as such it furnishes evidence as to the correctness of the refraction co-efficient adopted.

‡ The extent of the range of variation affords no useful information unless the same value for refraction has been employed throughout. By using selected values of refraction we can make all values of height identical and have no range of variation at all.

If no correction for refraction be applied, the values of height vary from 28353 to 29651, a discrepancy of 1298 feet: the 7th and 8th columns show how this discrepancy can be reduced by corrections for refraction.

The following table shows how the height of Dhaulagiri was obtained: no observations have been taken to it from stations in the hills:—

Deduction of the height of Dhaulagiri.

TABLE XI.—Height of Dhaulagiri.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Dhaulagiri.	Values of height, if no correction for refraction be applied.	Resulting height as determined by Waugh with co-efficients of refraction varying from 0·07 to 0·09.	Resulting height with assumed co-efficient of refraction 0·0645.
		Feet.	Miles.	Feet.	Feet.	Feet.
Morairi	1848	334	105·975	27974	26791·0	27002
Banarsi	1849	329	95·625	27928	26773·8	27128
Saonbarsa	1849	315	104·043	28093	26830·8	27151
Purena	1849	299	105·800	28011	26813·1	27044
Ghaos	1849	327	95·812	27852	26775·5	27052
Tulsipur	1848	376	104·461	27930	26824·8	26988
Anarkali	1848	434	137·340	28640	26756·6	27002
Mean	..	..	..	..	26795	27052
Range of variation in values *	..	..	..	788	Misleading.†	163

The height 26795 is too low: the reductions made on account of refraction were too great.

The observations in the North-West Himalaya of the great peaks of K², Nanga Parbat, etc., were taken not from low dusty hazy plains as those of the Nepalese peaks were, but from high stations, and the rays passed through a rarefied atmosphere.

Deduction of the height of K².

The height of K² was deduced by Colonel Montgomerie as follows:—

TABLE XII.—Height of K².

Station of observation.	Year of observation.	Height of station of observation.	Distance from K².	Values of height, if no correction for refraction be applied.	Resulting height as determined by Montgomerie with co-efficients of refraction varying from 0·04 to 0·05.
		Feet.	Miles.	Feet.	Feet.
Shangruti	1859	17531	78·9	28640	28246·6
Biachuthusa	1859	16746	99·0	28846	28218·7
Marshala	1858	16906	58·6	28472	28240·0
Kastor	1858	15983	66·0	28560	28261·4
Thurigo	1858	17246	61·8	28515	28254·1
Haramukh	1856	16001	136·5	29300	28293·9
Kanuri-Nar	1857	15437	114·3	28920	28218·4
Barwai	1857	16304	88·0	28666	28258·5
Tholanka	1857	16830	74·7	28613	28322·7
Mean	..	..	..	..	28253
Range of variation in values *	..	..	..	828	104

* The range of variation is the difference between the largest and smallest values of height in the column above; it is the maximum discordance obtained and as such it furnishes evidence as to the correctness of the refraction co-efficient adopted.

† The extent of the range of variation affords no useful information unless the same value for refraction has been employed throughout. By using selected values of refraction we can make all values of height identical and have no range of variation at all.

The following table shows the height of Nanga Parbat as deduced from the observ-
Deduction of the height of Nanga ations using different refraction co-efficients :—
Parbat.

TABLE XIII.—Height of Nanga Parbat.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Nanga Parbat.	HEIGHT WITH REFRACTION CO-EFFICIENTS OF										
				0·00	0·01	0·02	0·03	0·04	0·05	0·06	0·07	0·08	0·09	0·10
		Feet.	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Ahartatopa	1855	13029	133·744	27885	27646	27407	27168	26929	26689	26449	26210	25970	25734	25494
Pahargarh	1855	11356	118·751	27680	27492	27304	27116	26923	26739	26551	26362	26174	25988	25800
Gogipatri	1855	7752	95·055	27332	27211	27090	26969	26848	26726	26604	26485	26363	26243	26124
Haramukh	1856	16001	59·275	26882	26835	26788	26741	26694	26647	26599	26552	26505	26460	26413
Kajnag	1856	12111	73·559	27028	26956	26884	26812	26740	26669	26595	26524	26452	26380	26307
Poshkar	1856	8323	83·491	27219	27125	27031	26937	26843	26749	26654	26562	26468	26376	26282
Ismail-di-dori	1856	12630	63·805	26947	26892	26837	26782	26727	26671	26617	26563	26508	26454	26400
Safapur	1856	10296	66·339	26917	26858	26799	26740	26681	26624	26564	26506	26447	26387	26329
Hant	1856	13479	43·167	26771	26746	26721	26696	26671	26646	26621	26596	26572	26546	26522
Manganwar	1856	8715	56·510	26854	26811	26768	26725	26682	26638	26596	26553	26510	26467	26425
Marinag	1856	11814	46·342	26780	26751	26722	26693	26664	26636	26606	26579	26549	26520	26492
Mean	..	..	..	27118	27029	26941	26853	26764	26676	26587	26490	26411	26323	26235
Range of variation in values*	..	..	..	1114	900	686	475	265	125	205	386	602	812	1028

It will be noticed that when a co-efficient of 0·10 is used, the height of Nanga Parbat as determined from different places varies between 25494 and 26522, a range of 1028 feet.

This great variation shows that the co-efficient of 0·10 is inapplicable: with a co-efficient of 0·09 the height varies from 25734 to 26546, a range of 812 feet. The range of variation decreases, until with a co-efficient of 0·05 all the values of height fall between 26624 and 26749, a range of 125 feet. If we decrease the co-efficient still further to 0·04, the variations again begin to increase, and the range extends to 265 feet, from 26664 to 26929 : if the co-efficient be decreased to 0·00 the range of variation becomes 1114 feet.

The actual height adopted by Montgomerie for Nanga Parbat was 26620, and we are unable to improve upon his value : it is produced if a general co-efficient of 0·057 be accepted for refraction.

Is the great Himalaya range still rising ? This is a question often asked but which
The rise of the Himalaya. no one has been able to answer. The observations of peaks made between 1850 and 1860 were not sufficiently prolonged at any one station to enable us to rely with certainty on the values of height then obtained. When the absolute height of a peak is being measured, stations of observation have to be multiplied in order to cancel effects of refraction and gravity, but when a slow variation in height is being determined, it is better to carry out long series of observations from one station only. In the latter case differences are being sought, not absolute heights, and all that is necessary is to repeat observations

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* The range of variation is the difference between the largest and smallest values of height in the column above : it is the maximum discordance obtained and as such it furnishes evidence as to the correctness of the refraction co-efficient adopted.

from the same station, on the same days of the year, and under the same conditions. In 1905 a series of observations was commenced from the trigonometrical station of Nojli, and it is proposed to observe the heights of several peaks for some years and at different seasons in each year. If a reliable series of results be once obtained, a similar set of observations can be repeated at a subsequent date and any actual change of height that has occurred in the interim may be discovered.

The Siwalik range was elevated at a more recent date than the Himalaya, and is the most likely of all the ranges to be rising still : a bench-mark has been placed on the crest-line south of Dehra Dun, and its height has been determined by spirit levelling : if the bench-mark is preserved, future changes in altitude should be discoverable.

Slow changes in the level of land, unaccompanied by sudden movements, have been observed to occur along many coasts. At great distances from the sea such changes would take place without being noticed : without the aid of the sea as a datum we do not observe slow gradual movements, and a continuous rise of a foot a year might go on for centuries without attracting the attention of man. If an earthquake occurs and a tract of land suddenly subsides along a line of fracture in the crust, the result is apparent and measurable, but if the elevation of a large area takes place in all directions gradually and without fracture of the crust or any marked upheaval it may be considerable and yet escape observation. In the Dharmsala earthquake of 1905 an immense region may have been elevated or depressed through many feet, but if the change were nowhere sudden we should not without refined trigonometrical observations become aware of its occurrence.
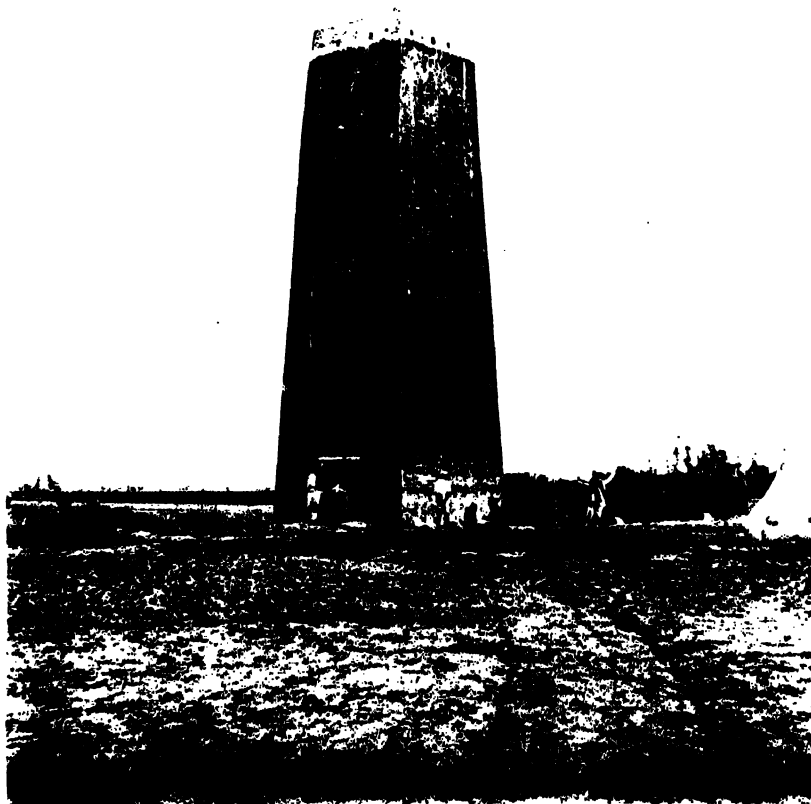
NOILI TOWER

A STATION OF THE GREAT TRIGONOMETRICAL SURVEY BUILT IN THE PLAINS OF UPPER INDIA NEAR ROORKEE
AND FROM WHICH THE HIMALAYAN PEAKS OF BADRI NATH KEDARNATH JAONLI AND BANDARPUNCH HAVE BEEN OBSERVED

FROM A PHOTOGRAPH BY C B LYMAN

5

ON THE FREQUENCY WITH WHICH PEAKS OF CERTAIN HEIGHTS TEND TO OCCUR.

Lest this review should degenerate into tables of numerical data we have refrained from continuing the lists of peaks below 24000 feet, but in deducing the continuity of ranges amid a vast mountainous area it is necessary to take into account the lower peaks.

The following table shows the total number of peaks exceeding 20000 feet that have been discovered. The chart forming the frontispiece illustrates the ranges to which the several peaks of the table have been allotted :—

TABLE XIV.—The numbers of peaks of different altitudes which have been discovered in Asia.

Region.	Range.	Between 20000 and 21000 feet.	Between 21000 and 22000 feet.	Between 22000 and 23000 feet.	Between 23000 and 24000 feet.	Peaks of 5th magnitude 24000 to 25000 feet.	Peaks of 4th magnitude 25000 to 26000 feet.	Peaks of 3rd magnitude 26000 to 27000 feet.	Peaks of 2nd magnitude 27000 to 28000 feet.	PEAKS OF FIRST MAGNITUDE. 28000 to 29000 feet.	PEAKS OF FIRST MAGNITUDE. Above 29000 feet.
Trans-Tibetan.	Tian Shan	..	..	..	1	..	..	..	..	..	..
	Trans Alai	..	1	1	..	..	..	..	..	..	..
	Kashgar	1	..	2	..	1	2	..	..	..	..
	Sarikol	1	..	..	..	..	..	..	..	..	..
North-West Tibet.	Kuen Lun	57	28	10	3	1	..	..	..	..	..
	Aghil	24	2	1	..	..	..	..	..	..	..
	Karakoram	92	71	28	10	7	10	4	..	1	..
	Hindu Kush	49	29	13	9	3	1	..	..	..	..
Southern Tibet.	Kailas, West	9	8	5	..	2	1	..	..	..	..
	Kailas, East	11	12	..	2	..	..	..	..	..	..
	Ladak, West	11	5	1	..	..	..	..	..	..	..
	Ladak, East	11	12	5	..	..	1	..	..	..	..
	Ninchinthangla	5	3	1	1	..	..	..	..	..	..
	Zaskar	20	11	6	2	..	1	..	..	..	..
Himalaya .	Great Himalaya range— (In Assam)	9	3	6	6	3	..	..	..	..	..
	(In Nepal)	15	35	33	17	9	13	6	2	1	1
	(In Kumaun)	27	24	32	9	1	2	..	..	..	..
	(In Punjab)	7	6	2	2	..	1	1	..	..	..
Himalaya .	Lesser Himalaya range (between Kulu and Lahaul)	5	..	..	..	..	..	..	..	..	..
	Total	354	250	146	62	27	32	11	2	2	1

Russian surveyors probably know of more peaks exceeding 20000 feet than we have been able to allot to the Tian Shan and Trans Alai ranges : but they have only discovered one peak above 23000 feet,—Tengri Khan (*vide* table VI). The highest peak of the Trans Alai range is Kaufmann (table VI).

Twenty-seven peaks exceeding 20000 feet have been allotted in the table to the Aghil range : these peaks when plotted appear to stand between the Karakoram and Kuen Lun ranges, but they are insufficient in number to enable the intervening ranges to be traced : it is possible that some of these peaks belong properly to the Karakoram range and some to the Kuen Lun : no certain distribution can be made at present, and the trend of the Aghil range as shown on the frontispiece chart must be regarded as problematical.

The single peak of the Ladak range that exceeds 25000 feet in height is Gurla Mandhata : the great peak of the Zaskar range is Kamet : the highest peak of the Kailas range is Rakaposhi.   The Kailas and Ladak ranges have for convenience been divided into east and west sections at lake Manasarowar.

The totals in table XIV show us that more peaks of the fourth magnitude have been discovered than of the fifth.   This phenomenon

The effect of snow upon heights.

is so striking that it is necessary to consider whether it can be due in any way to snow-fall,—whether there can exist some critical altitude at which a maximum amount of snow tends to accumulate.

The term " snow-line " is the line through a mountain region along which the quantity of snow that falls annually is equal to the quantity that is melted annually ; below this line more snow can be melted in a year than actually falls ; above the snow-line more snow falls than can be melted.   In the Kumaun Himalaya the snow-line was determined by General Richard Strachey to be 15500 feet on the south side of the great range and 18500 feet on the north side.*

As we ascend above the snow-line, we find the depth of perpetual snow tending to increase, but we do not know at what altitude in any given region the accumulation becomes a maximum.   As the altitude increases, less snow is melted in the year, but the amounts removed by wind and evaporation may for what we know to the contrary be greater : the snow-fall moreover itself decreases with height, and at a certain altitude the decrease in fall begins to produce a diminution in the amount annually accumulated.

The problem is complicated too by considerations other than meteorological.   A flat-topped summit will accumulate greater masses of snow than a precipitous and pointed peak.   Mountains such as K², Nanga Parbat, or Rakaposhi are too sharp to allow the snow to lie in quantity ; as soon as snow falls upon them it descends in the form of avalanches to lower levels and hardens into glacier-ice.   But the great Tirich Mir group of peaks have rounded tops, which have possibly been formed by constant accumulations of snow.

The question is therefore not simply one of the balance of snow-fall and melting, for the shape of a peak is a most important factor.   The peaks on which snow has been accumulating for centuries are those possessing flat tops, and as flat tops are not more likely to occur at one altitude than at another, it is not possible to attribute

* *Vide* Section 19, Part II of this paper.

the great number of peaks of the fourth magnitude to excessive accumulations of snow at 25000 feet.

In the Himalayan system of ranges the great peaks may be divided into twelve

Peaks of 24000 feet are compara-tively rare.

groups : in two the principal peaks exceed 28000 feet, in five the principals lie between 26000 and 27000 feet, in three between 25000 and 26000, and in only two are the principals between 24000 and 25000.*

In the Karakoram system the same paucity of 24000 feet peaks is observed : one group surrounds a principal exceeding 28000 feet ; seven groups surround principals of 25000 feet, and in two groups only are the principals of 24000 feet.

In the Himalayan system there are many groups of peaks the principals of which rise to 23000 feet : amongst others table vi shows Api (23399 feet), Badri-nath (23190 feet), Chumalhari (23930 feet), Dayabhang (23750 feet), Gaurisankar (23440 feet), Ser or Nana (23410 feet).

So far then as observations have gone, peaks of 24000 feet have been found to be relatively rare, and principals of groups of that height very rare. At the same time the incompleteness of the trigonometrical survey has to be borne in mind ; the peaks of Nepal were observed from very distant stations situated on the low-lying plains of India, and some are known to have been hidden from observers by clouds. A trigonometrical surveyor has no fixed observatory in which he can wait with patience for clear days : he has to observe from many stations in the course of a year, and has always to be moving forward. In observing important peaks he may consider it justifiable to delay for days to ensure that no great altitude has been missed, but some of the minor peaks may be lost, if clouds are persistent.

For weeks together the snow-peaks will be visible for a short time after sunrise, and then become obscured for the rest of the day by clouds or dust-haze rising off the plains : the surveyor utilises the few minutes at his disposal in observing carefully the principal peaks in view, but he has not the time to make an exhaustive study of the range. So long as the Nepal peaks have to be observed from distances of 100 miles the trigonometrical survey will remain incomplete.†

In view of the known incompleteness of the survey, as a whole, a discussion of the numbers of peaks of the fourth and fifth magnitudes may be considered superfluous. But though the data are insufficient to justify conclusions being drawn, observed pecu-liarities are deserving of notice. The surface features of the solid earth do conform generally to the laws of probability : half the whole surface of the lithosphere is situated within 700 feet of sea-level, and the highest heights and the deepest deeps occur very rarely. It was reasonable to expect that we should discover more peaks of 20000 feet than of 21000 feet and more of 23000 feet than of 24000, and this we have done : but

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* The actual number of Himalayan groups is ten ; Kamet and Gurla Mandhata raise the total to twelve.

† The Kumaun and Punjab Himalaya have however been very closely examined and the absence of peaks of 24000 feet is more marked than in Nepal.

Colonel Tanner, who observed the peaks of Nepal from many different places, with the object of supplementing the previous observations of the Great Trigonometrical Survey, wrote " Very few of the great peaks escaped the observers of " the Trigonometrical Survey."

F

there is one striking exception to the rule,—*the peaks of the fourth magnitude exceed in number those of the fifth.*

From present data it is difficult to calculate by the law of probability how many
peaks of any particular altitude may be expected to
Application of the law of probability.
exist in a given region ; we have as yet no satisfactory
basis. We cannot, for instance, take the peaks of 20000 and 21000 feet as our data
and deduce from them the probable numbers of other heights, because we know that
many peaks of 20000 and 21000 feet have escaped our surveyors and that our
observed numbers are in defect of reality.

We can calculate the probable numbers of peaks upon the hypothesis that all
existing peaks above 26000 feet have been discovered, but this hypothesis is not satis-
factory as it gives undue weight to the few highest peaks.

Finally, we can take the peaks of 25000 and 26000 feet, and assuming that no
others of such heights exist undiscovered, we can deduce the probable number of
peaks of all heights. The objection to this hypothesis is that there are reasons for
believing that the number of peaks of 25000 feet is larger than the law of probability
would give.

In the following table is shown the number of peaks of each altitude that the
law of probability would lead us to expect to find :—

TABLE XV.—Comparisons between probable and actual numbers.

Height in feet.	Probable number of peaks on the assumption that there exist eleven between 26000 and 27000 and one peak above 29000 feet.	Actual number of peaks discovered.	Discrepancy between probables and actuals.	Probable number of peaks on the assumption that there exist eleven peaks between 26000 and 27000 and thirty-two between 25000 and 26000 feet.	Actual number of peaks discovered.	Discrepancy between probables and actuals.
Above 29000	1	1	0	1	1	0
Between 28000 and 29000..	2	2	0	1	2	+1
„ 27000 and 28000..	5	2	—3	4	2	—2
„ 26000 and 27000..	11	11	0	11	11	0
„ 25000 and 26000..	23	32	+9	32	32	0
„ 24000 and 25000..	47	27	—20	84	27	—57
„ 23000 and 24000..	93	62	—31	218	62	—156
„ 22000 and 23000..	179	146	—33	544	146	—398
„ 21000 and 22000..	335	250	—85	1302	250	—1052
„ 20000 and 21000..	607	354	—253	2996	354	—2642

In the first half of this table the probable numbers are calculated on the assump-
tion that eleven peaks between 26000 and 27000 feet exist and one peak of 29000
feet. On this assumption the actual number of peaks below 25000 feet is shown
throughout to be less than the probable number,—a deficiency that can only be regarded

as reasonable seeing that many peaks of these heights are known to be still unobserved. The curious feature of this portion of the table is that the actual number of peaks between 25000 and 26000 feet exceeds the probable number by 9. The meaning of this excess is that *the number of existing peaks between 25000 and 26000 feet is greater than would be expected from the number known to exist above 26000 feet.*

In the second half of the table the probable numbers have been calculated on the assumption that eleven peaks exist between 26000 and 27000 feet and thirty-two between 25000 and 26000 feet. The result of including these thirty-two peaks in the data is to increase greatly the numbers of inferior peaks : the increase becomes enormous if the table is extended down to 16000 feet,* and the numbers of peaks then shown as probably existing are clearly in excess of the actuals. The meaning of this excess is that *the number of existing peaks between 25000 and 26000 feet is greater than would be expected from the number believed to exist below 25000 feet.*

Whilst then we recognise the insufficiency of our data, we think that the results of table xv are not without interest : we find from that table that the number of peaks between 25000 and 26000 feet is unduly great, whether they be compared with those *above* 26000 or with those *below* 25000 feet.

The height of the rock summit of a peak is the resultant effect of two forces,—(i) the force of compression which elevated the range, (ii) the erosive force which is lowering the range. The rock summit is covered by an unknown amount of snow. If we reject the snow-covering as insignificant in effect, we shall have to assume that the combined actions of the compressing and eroding forces have tended to produce in Asia an exceptional number of peaks attaining 25000 feet.

* Probable numbers of peaks :

Height in feet.	Basis of calculation : one peak above 29000, eleven peaks between 26000 and 27000 feet.	Basis of calculation : eleven peaks between 26000 and 27000, thirty-two peaks between 25000 and 26000 feet.
Between 19000 and 20000	1070	6616
„ 18000 and 19000	1833	14030
„ 17000 and 18000	3048	28566
„ 16000 and 17000	4923	55848

6

ON THE GEOGRAPHICAL DISTRIBUTION OF THE GREAT PEAKS.

One of the difficulties encountered in the classification of mountain-peaks is that absolute altitude is not a true indication of regional importance.

The presence of a peak of 20000 feet that surpasses in height all other surrounding summits furnishes more instructive lessons than one like Jano (25294 feet), which is a mere projection from a buttress of Kinchinjunga.

Peaks may in fact be divided into four classes according to their relative local importance :

    (i) There is the *principal* of a group like Everest (29002 feet) or Tirich Mir (25426 feet).

    (ii) There is the *twin* of the principal like Kinchinjunga II (27803 feet) or Mer (23250 feet)—situated in close proximity to the principal and rivalling it in altitude.

    (iii) There is the *companion* like Makalu or Gasherbrum, which situated in the vicinity of the principal is 1000 or perhaps 2000 feet lower.

    (iv) There is the *satellite* like Jano or Kabru, 3000 or 4000 feet lower than the principal.

In the following table the great peaks of the Himalaya are divided into regional groups : those that are twins are marked by an asterisk. The numbers of the peaks are taken from tables I to V of this paper.

TABLE XVI.—An analysis of the great peaks of the Himalayan system.

Groups as numbered from east to west	Position of the group	Number of great peaks in the group	The great peaks	Height. Feet.	Position of each peak in the group.	Notes.
Group I (Kulha Kangri).	The eastern-most group.	3	No. 51*	24740		
			" 54*	24660	3000 yards N. N. W. of No. 51.	
			" 59	24496	15 miles N. E. of No. 51.	
Group II (Kinchinjunga).	140 miles west of group I.	7	No. 3* Kinchinjunga	28146		
			" 4*	27803	1600 yards S. S. E. of No. 3.	
			" 20 Kambachen	25782	1 mile N. of No. 3.	
			" 37 Jano	25294	6 miles W. of No. 3.	
			" 64	24344	11 miles N. of No. 3.	
			" 72	24089	6 miles N. N. E. of No. 3.	
			" 75 Kabru	24002	6 miles S. of No. 3.	
Group III (Everest)	63 miles west of group II.	9	No. 1 Mount Everest	29002	A single pyramid.	If we analyse group III we see that Everest stands alone on the Tibetan side of the crest, that no other great peak is within 10 miles of it, and that 5 peaks are crowded together 15 miles to the W. N. W. It is known that the list of the peaks of the Everest group is incomplete: during the observations by the Great Trigonometrical Survey and subsequently during those by Colonel Tanner, the group was persistently obscured by clouds, and some high peaks to the S. W. of Everest were lost. They were seen several times and observed more than once, but their shapes were not sufficiently distinguished through the hazy atmosphere and amid the distant clouds to admit of their identification from two points.
			" 5 Makalu	27790	12 miles S. E. of No. 1.	
			" 6	26867	16 miles W. N. W. of No. 1.	
			" 17*	25990	13 miles W. N. W. of No. 1 and 5 miles from No. 6.	
			" 18*	25909	14 miles W. N. W. of No. 1 and 2 miles from No. 6.	
			" 30	25433	20 miles W. N. W. of No. 1 and 3 miles from No. 6.	
			" 33	25413	12 miles E. S. E. of No. 1 and 2 miles from No. 5.	
			" 40	25202	15 miles W. N. W. of No. 1 and 3 miles from No. 6.	
			" 74 Chamlang	24012	15 miles S. S. E. of No. 1.	

TABLE XVI.—*continued.*

Groups as numbered from east to west.	Position of the group.	Number of great peaks in the group.	The great peaks.	Height.	Position of each peak in the group.	Notes.
				Feet.		
Group IV (Gossainthan).	60 miles west of group III.	2	No. 13 Gossainthan " 43*	26291 25134	2 miles E. of No. 13.	
Group V	39 miles west of group IV.	1	No. 67	24299		
Group VI	34 miles west of group V.	3	No. 8 " 19 " 21	26658 25801 25705	10 miles S. E. of No. 8. 3 miles S. of No. 8.	
Group VII	26 miles west of group VI.	4	No. 10 " 15 " 50 " 53	26492 26041 24750 24688	18 miles E. of No. 10. 10 miles E. of No. 10. 16 miles E. of No. 10.	
Group VIII (Dhaulagiri).	21 miles west of group VII.	6	No. 7 Dhaulagiri " 31* " 39* " 46 " 49 " 70	26795 25429 25271 25064 24885 24150	7 miles W. N. W. of No. 7. 8 miles W. N. W. of No. 7. 11 miles W. N. W. of No. 7. 9 miles W. N. W. of No. 7. 17 miles W. N. W. of No. 7.	No. 49 is on the same ridge and in the same alignment as Nos. 31 and 39. No. 39 stands in the centre of the ridge, with No. 31 at a distance of 0·90 mile N. E. and with No. 49 at a distance of 2·51 miles S. W. This ridge is a rare example of a linear summit surmounted by 3 great peaks of almost the same altitude.
Group IX (Kumaun).	250 miles west of group VIII.	3	No. 23* Nanda Devi " 26* " 61	25645 25563 24391	Within 100 yards of No. 23. 1½ miles E. S. E. of No. 23.	No. 61 stands in the prolongation of the ridge connecting the Nanda Devi twins. This is an example of a three-peaked linear summit.
Distant outliers of the Kumaun group.		2	No. 29 Kamet " 36 Gurla Mandhata	25447 25355	40 miles N. N. W. of No. 23. 80 miles E. of No. 23.	These peaks are in Tibet and are not situated on the Great Himalaya range itself: their presence indicates that the Tibetan ranges beyond the Himalaya have been exceptionally elevated north of Kumaun.
Group X (Kashmir).	468 miles west of group IX.	2	No. 9 Nanga Parbat " 25	26620 25572	1 mile N. N. W. of No. 9.	Throughout the great distance of 458 miles separating groups IX and X no known peak exists exceeding 4000 feet in height.

BANDAP PEAK

NANGA PARBAT

AS SEEN FROM A DISTANCE OF 100 MILES

Out of the 75 peaks of Asia that are known to exceed 24000 feet in height, 42 have been distributed amongst the ten groups above and may be regarded as belonging to the Himalayan system.

TABLE XVII.—Summary of Himalayan peaks.

No. of group.	Name of group.	No. of great peaks exceeding 24000 feet.
I	Kulha Kangri	3
II	Kinchinjunga	7
III	Everest	9
IV	Gosainthan	2
V	. . . .	1
VI	. . . .	3
VII	. . . .	4
VIII	Dhaulagiri	6
IX	Kumaun	3
X	Kashmir	2
	Total number of great peaks on Himalayan range	40
	Total number of Trans-Himalayan great peaks north of Kumaun group.	2
	Total	42

We described on page 10 how few peaks were really peaked in the true sense of the word; and of true peaks there is hardly one that can be accurately described as solitary. Nanga Parbat (26620 feet) is the most famous example of a solitary cone, but even Nanga Parbat has a companion (25572 feet) standing at a distance of a mile and a satellite (23170 feet) within 3 miles.

Gurla Mandhata is often described as a solitary peak, but it has two satellites : one of these, 22846 feet in height, stands 2 miles N. of its principal ; the other is 22673 feet and 3 miles E.N.E.

Kamet appears on the charts to be standing alone on the border of Tibet, but the peak of Mana (23862 feet) is within 3 miles of it.

The accompanying plate contains two drawings by Colonel George Strahan, R.E. That of Nanga Parbat furnishes a fine example of a solitary peak. The other shows the twin peaks of Bandarpunch with their connecting ridge resembling a suspended chain ; these twin peaks are 3000 yards apart and 20720 and 20017 feet in height respectively.

Of the great peaks of Asia the thirty-three that stand north of the Indus may be considered as belonging to the Karakoram system.† In the following table they are divided into regional groups. Throughout this system twin peaks are a common form of summit; they are marked with an asterisk in the table. The distinguishing numbers of the several peaks are taken from tables I to V of this paper.

TABLE XVIII.—An analysis of the great peaks of the Karakoram system.

Groups as numbered from east to west	Position of the group.	Number of great peaks in the group.	The great peaks.	Height. (Feet)	Position of each peak in the group.	Notes.
Group XI (Shyok Nubra).	Between Shyok and Nubra rivers.	3	No. 41 " 55* " 57*	25170 24650 24590	 5 miles S. E. of No. 41. 3 miles S. E. of No. 41.	
Group XII	20 miles west of group XI.	1	No. 52	24690		
Group XIII	35 miles from No. 52.	3	No. 34* K¹ " 38* K¹¹ " 63 K¹²	25400 25280 24370	Within ½ a mile of one another. 13 miles S. E. of No. 34.	
Group XIV (Karakoram).	22 miles west of group XIII.	9	No. 2 K² " 11* K³ Gasherbrum " 12* " 14* " 16* " 22* Masherbrum " 24* • " 45	28250 26470 26360 26090 26000 25660 25610 25110	The Gasherbrum quadruplet comprising 4 great peaks standing on a crescentic line 5 miles long is situated some 11 or 12 miles to the S. E. of K². 18 miles S. W. of K². 18 miles S. of K². 11 miles S. S. W. of Gasherbrum. 16 miles E. S. E. of Masherbrum.	Gasherbrum furnishes the only instance amongst the great peaks of so many as 4 of equal altitude being situated on one ridge. Two of the peaks Nos. 12 and 14 are within 1200 yards of one another, a third No. 16 lies in the alignment 2 miles to the east, and a fourth No. 11 lies two miles to the west. Peaks Nos. 22, 24 and 45 are situated in the prolongation of the alignment in which the groups XI, XII and XIII are ranged, but K² and the four Gasherbrum peaks are situated on a parallel alignment some 15 or 16 miles to the N.E. It is possible that the summit of the range is corrugated, and that there are two distinct folds, the Gasherbrum peaks standing on the one, the Masherbrum on the other. The Karakoram group is very complicated: its seven peaks lie on the perimeter of an oblong area, which extends for 15 miles, in the direction of the range and for 18 miles astride the range. K² is at the northern corner of the oblong, Masherbrum is at the western corner and Gasherbrum at the eastern corner. No great peak has been discovered inside this area.

† For name "Karakoram" see Section 16 of Part II.

TABLE XVIII—continued.

Groups as numbered from east to west.	Position of the group.	Number of great peaks in the group.	The great peaks.	Height. Feet.	Position of each peak in the group.	Notes.
Group XV (Kunjut).	60 miles west of group XIV.	3	No. 28 „ 58 „ 71	25400 24580 24090	10 miles W. of No. 28. 24 miles W.N.W. of No. 28.	There are many peaks of 22000 and 23000 feet in this group. A curvilinear alignment of peaks exceeding 20000 feet can be traced westwards from the Hunza-Kunji group for 80 miles: it is then broken by the Kunar river, but the continuation of the alignment can be traced for a further 60 miles as far as the great group of Tirich Mir.
Group XVI (Hunza Kunji).	22 miles west of group XV.	4	No. 35 „ 44 „ 47 „ 73 Hunza-Kunji.	25370 25118 25650 24444	2 miles N.N.W. of No. 35. 11 miles E.S.E. of No. 35. 13 miles E.S.E. of No. 35.	
Group XVII (Tirich Mir).	140 miles west of group XVI.	4	No. 32 Tirich Mir „ 56 * „ 65 * „ 69 Sad I-Istragh	25426 24611 24343 24171	10 miles N. of No. 32. 9 miles N.N.E. of No. 32. 26 miles N.E. of No. 32.	To the westward of Tirich Mir no great peaks have been discovered.
Group XVIII	Between the Indus river and the Karak-ram range.	3	No. 27 Rakaposhi „ 60 * „ 68 Haramosh	25550 24470 24270	25 miles E.S.E. of No. 27. 32 miles S.E. of No. 27.	This group stands north of the Indus, but south of the Karakoram range: its peaks are separated by so great distances that they can hardly be described as composing one group: they are however all situated on the same range, and are the only great peaks of that range: they can therefore be conveniently classed together. On the frontispiece chart this range has been designated the Kailas range.
Group XIX (Kashgar).	East of the Pamir plateau.	3	No. 42 Kashgar „ 48 * „ 62 Muzta-gh Ata.	25146 25046 24388	7 miles E.S.E. of No. 42. 28 miles S.S.W. of No. 42.	These three peaks are on the Kashgar range (see frontispiece chart): they are isolated, being 140 miles from the nearest group.
Group XX (Kuen Lun).	North-West Tibet.	1	No. 66 Kuen Lun.	24396		The only peak of the Kuen Lun range that has been found to exceed 24000 feet in height.

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The ten groups of the Karakoram system may now be summarised :—

TABLE XIX.—Summary of Karakoram peaks.

No. of group.	Name of group.	No. of great peaks exceeding 24000 feet.
XI	Shyok Nubra	3
XII	. . . .	1
XIII	. . . .	3
XIV	Karakoram	8
XV	Kunjut	3
XVI	Hunza-Kunji	4
XVII	Tirich Mir	4
	Total number of great peaks on the Karakoram range . .	26
XVIII	Great peaks between the Indus river and the Karakoram range	3
XIX & XX	Great peaks north of the Karakoram range	4
	Total number of great peaks in the Karakoram system . .	33

Colonel Tanner has pointed out that the imposing appearance of a peak depends not on absolute height but on the amount of its slope exposed to view, and he gave the following table of peaks which he had observed, to show the superiority in appearance of Nanga Parbat.

TABLE XX.

Name of peak.	As seen from	Distance.	Height of slope exposed to view.
		Miles.	Feet.
Mount Everest . .	Purnea, Bengal	118	8000
Mount Everest .	Sandakphu on Singalila ridge	90	12000
Makalu . . .	Purnea, Bengal	120	8000
Makalu . . .	Sandakphu	79	9000
Nanga Parbat .	From the right bank of the Indus	40	23000
Tirich Mir . .	On the road from Gilgit to Chitral	40	18000
Rakaposhi . .	Chaprot	40	18000
Kinchinjunga . .	Darjeeling	46	16000

7

THE GEOLOGY OF THE GREAT PEAKS.

In dealing with the great peaks the geologist is at no small disadvantage as compared with the surveyor, whose instruments enable him to work from a distance and to fix with accuracy the position and height of the object of his observation. The geologist, on the other hand, must toil arduously up the mountain sides, examining at close quarters such outcrops of rocks as he can find clear of snow, and, where further progress is barred, must depend for his information on fallen fragments, splintered from the cliffs above and brought down by avalanches and glaciers to form moraines and talus heaps. Thus the composition of the highest peaks is rarely known in any detail, but the general character of the rocks can be ascertained, with a fair approximation to certainty, from observation of the material on their flanks, and from a distant view of the weathering characters and apparent structure of the peaks themselves: it has thus been found that almost all those of 25000 feet or more in height are composed of granite, gneiss, and associated crystalline rocks.

Of the granite there are at least two varieties, a foliated rock composed essentially of quartz, felspar, and biotite (black mica), and a younger non-foliated form containing, in addition to quartz and felspar, white mica (muscovite), black tourmaline, beryl, and various accessory minerals. The former variety was long regarded as a sedimentary rock which had been converted by heat and pressure into gneiss, but its truly intrusive nature was recognised by the late Lieutenant-General C. A. McMahon,* who proved conclusively that the great central gneissose rock of the Himalaya was in reality a granite crushed and foliated by pressure. This rock is frequently pierced by veins of the second or non-foliated variety, and where these run parallel to the foliation planes, they lend to the series a deceptive appearance of bedding and cause it, when seen from a distance, to be mistaken for a mass of stratified deposits. This is a common characteristic of the higher peaks and may be noticed in many of the granitic masses of the great Himalayan range.

Although our experience leads us to assume that all the highest peaks are composed largely of granite, many more observations must be made before this can be positively asserted to be the case. Thus the most important mass of all, the Everest group, is still a blank on our geological maps, and so also is Kulha Kangri in Bhutan. Between these two, however, we know that all the most important peaks are formed of granite. Thus Chumalhari (23930 feet) is composed of foliated (gneissose) granite penetrated by veins of the non-foliated variety, and flanked by the altered representatives of slates and limestones metamorphosed by the granite which has been forced up through them from below. Further to the west, the Kinchinjunga group is also formed of granite,† flanked by metamorphic rocks certainly in part derived from pre-existing

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* *Records, Geological Survey of India,* Vol. XV (1882), p. 44. Vol. XVI (1883), p. 129, and *Geological Magazine,* Dec. III. Volume 4 (1887), p. 215.

† E. J. Garwood in D. W. Freshfield's *Round Kangchenjunga* (1903).

sediments but re-arranged and recrystallised by heat and pressure and converted into various forms of gneiss and schist. Owing to the rigid exclusion of British travellers from Nepal, we know little or nothing of the geological characters of the highest mountain in the world, since practically the whole country is still unsurveyed. It is probable, however, that, like Kinchinjunga, the Everest group is composed chiefly of granite and gneiss.

To the west of Nepal we are on surer ground, since both Kumaun and Garhwal have been geologically surveyed. Here again the high peaks, such as Nanda Devi, the Kedarnath group, and Kamet,* are all composed of granite and gneiss with gneiss and schist on their flanks. The same may be said of most of the high peaks of Kashmir, including Nanga Parbat, Rakaposhi, and K2,† while granite is also probably the prevailing rock on Muztagh Ata and the other high peaks of the Kashgar range.

This correspondence between the great elevation and the geological structure of the high peaks appears to be too constant to be attributable to mere coincidence, and we are forced to the conclusion that their exceptional height is due to the presence of granite. This may be explained on two separate grounds, either (a) that the superior power of the granite to resist the atmospheric forces tending to their degradation has caused them to stand as isolated masses above surrounding areas of more easily eroded rocks, or (b) that they are areas of special elevation.

If now we examine the relationships of the peaks to one another, we find that along certain definite lines the intervening areas are also frequently composed of the same granite as the peaks themselves, and if we follow these definite lines we further find that they constitute the axes of the great mountain ranges. Thus the great peaks lie on more or less continuous and elevated zones composed of granite and crystalline rocks, and since the lower portions of the zones are of the same composition as the peaks themselves, it is difficult to regard the latter merely as relics of a once continuous zone of uniform height, and it seems probable that special elevating forces have been at work to raise certain parts of the zone above the general level of the whole; when once such elevation has been brought about, the disparity between the higher peaks and the intervening less elevated areas would undoubtedly be intensified by the destructive forces at work; the mantle of snow and ice, while slowly carrying on its own work of abrasion, will serve as a protection for the peaks against the disintegrating forces of the atmosphere, whilst the lower unprotected areas will be more rapidly eroded.

By the assumption that the higher peaks are due to special elevatory forces, it is not intended to imply that each peak is the result of an independent movement, for it has already been shown in a previous section of this paper that the peaks occur in well-marked clusters, any one of which may cover an area of many hundred square miles: when, therefore, during the development of the Himalaya as a mighty mountain range vast masses of granite welled up from below, forcing their way through and lifting up

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* C. L. Griesbach, *Memoirs, Geological Survey of India*, Vol. XXIII (1891).
† R. Lydekker, *Memoirs, Geological Survey of India*, Vol. XXII (1883).

the pre-existing rocks above, it is probable that owing to dissimilarity of composition and structural weaknesses in certain portions of the earth's crust, movement was more intense at some points than at others, and that the granite was locally raised into more or less dome-like masses standing above the general level of the growing range : these masses were subsequently carved by the process of erosion into clusters of peaks. Whether the elevatory movement is still in progress it is not at present possible to say, but many phenomena observable throughout the Himalaya and Tibet lead us to infer that local elevation has until quite recently been operative, and the numerous earthquakes still occurring with such violence and frequency forcibly remind us that the Himalaya have by no means reached a period of even comparative rest.
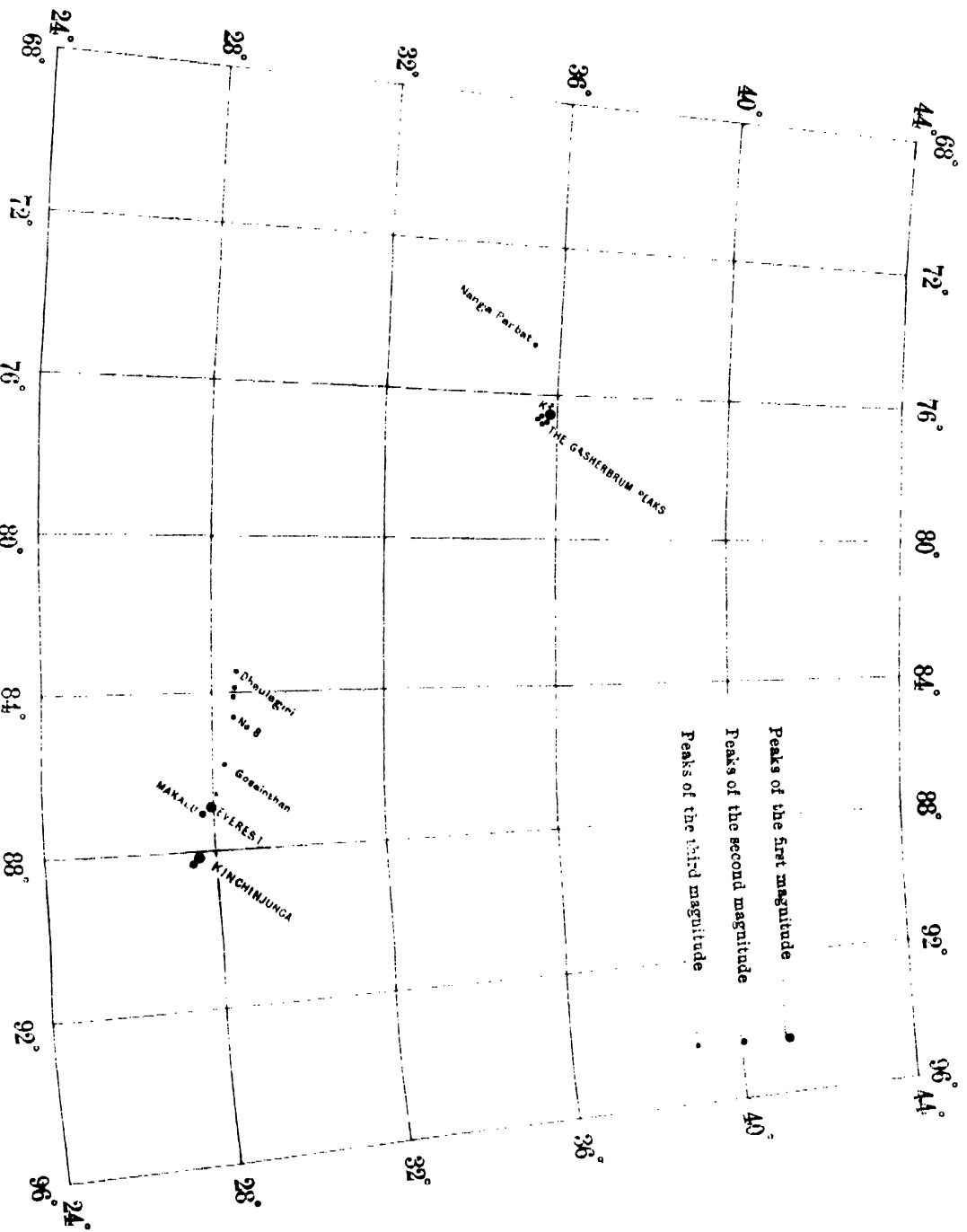
CHART I

PEAKS OF THE FIRST MAGNITUDE
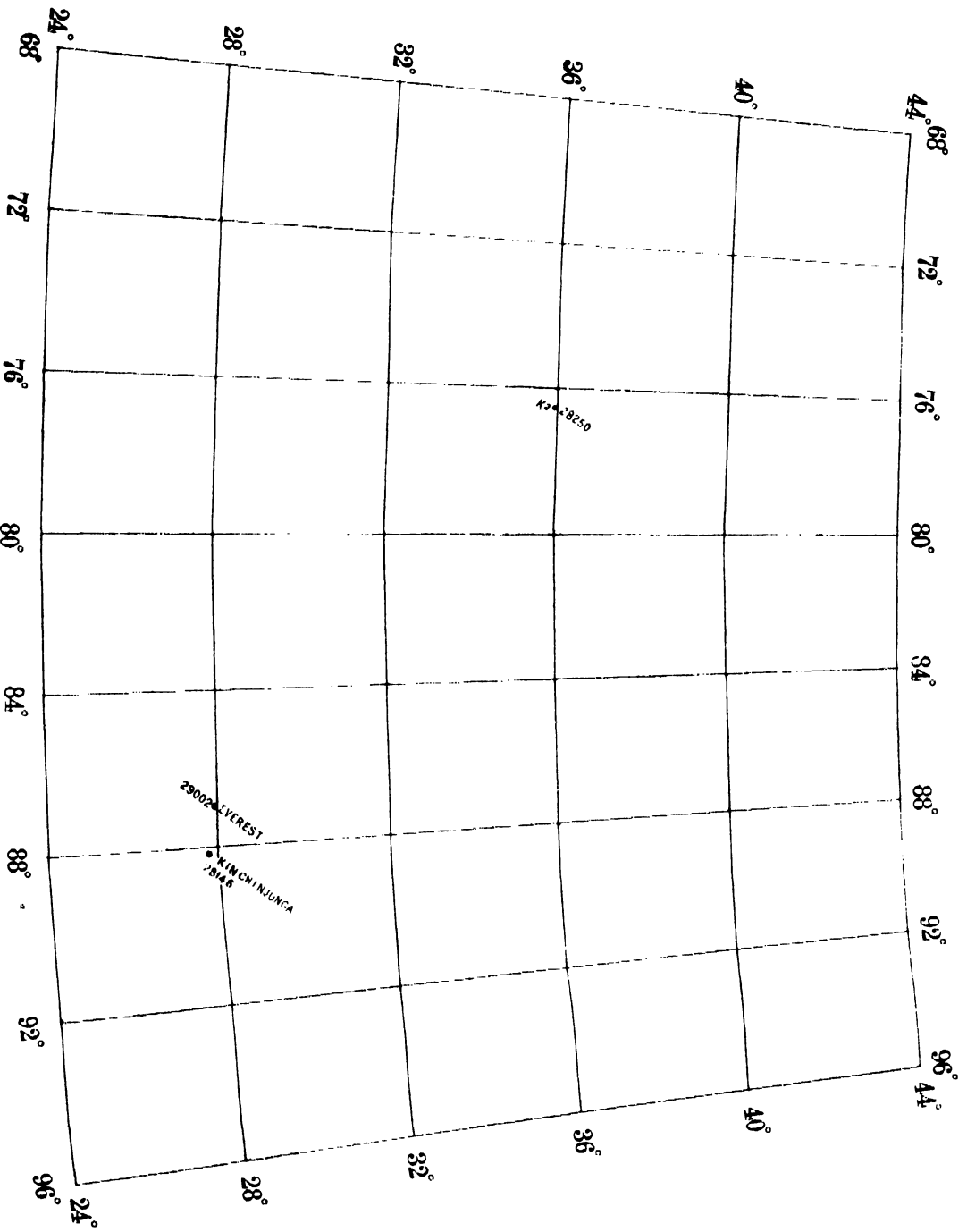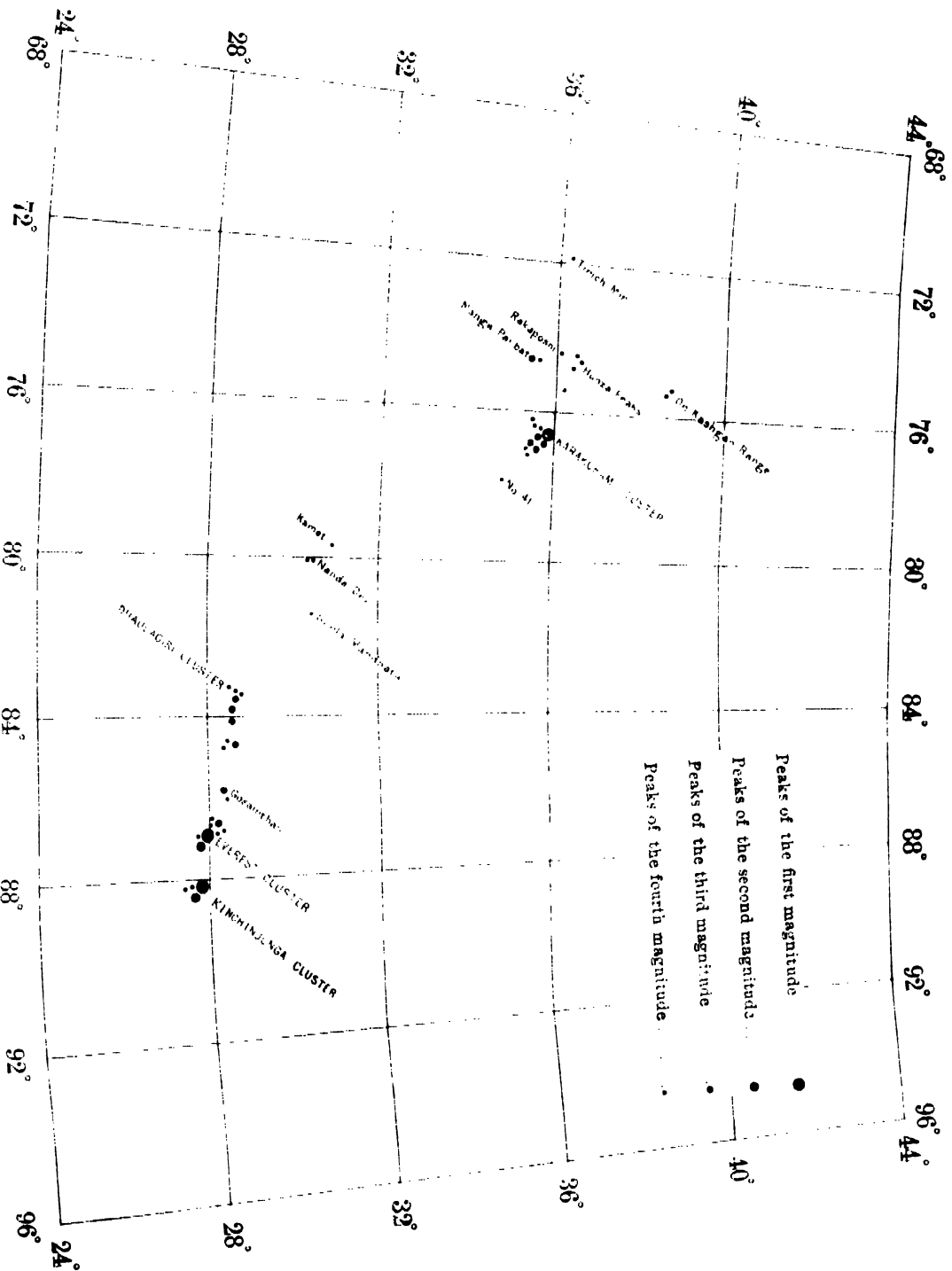
CHART II

PEAKS OF THE SECOND AND FIRST MAGNITUDE

Peaks of the first magnitude

Peaks of the second magnitude
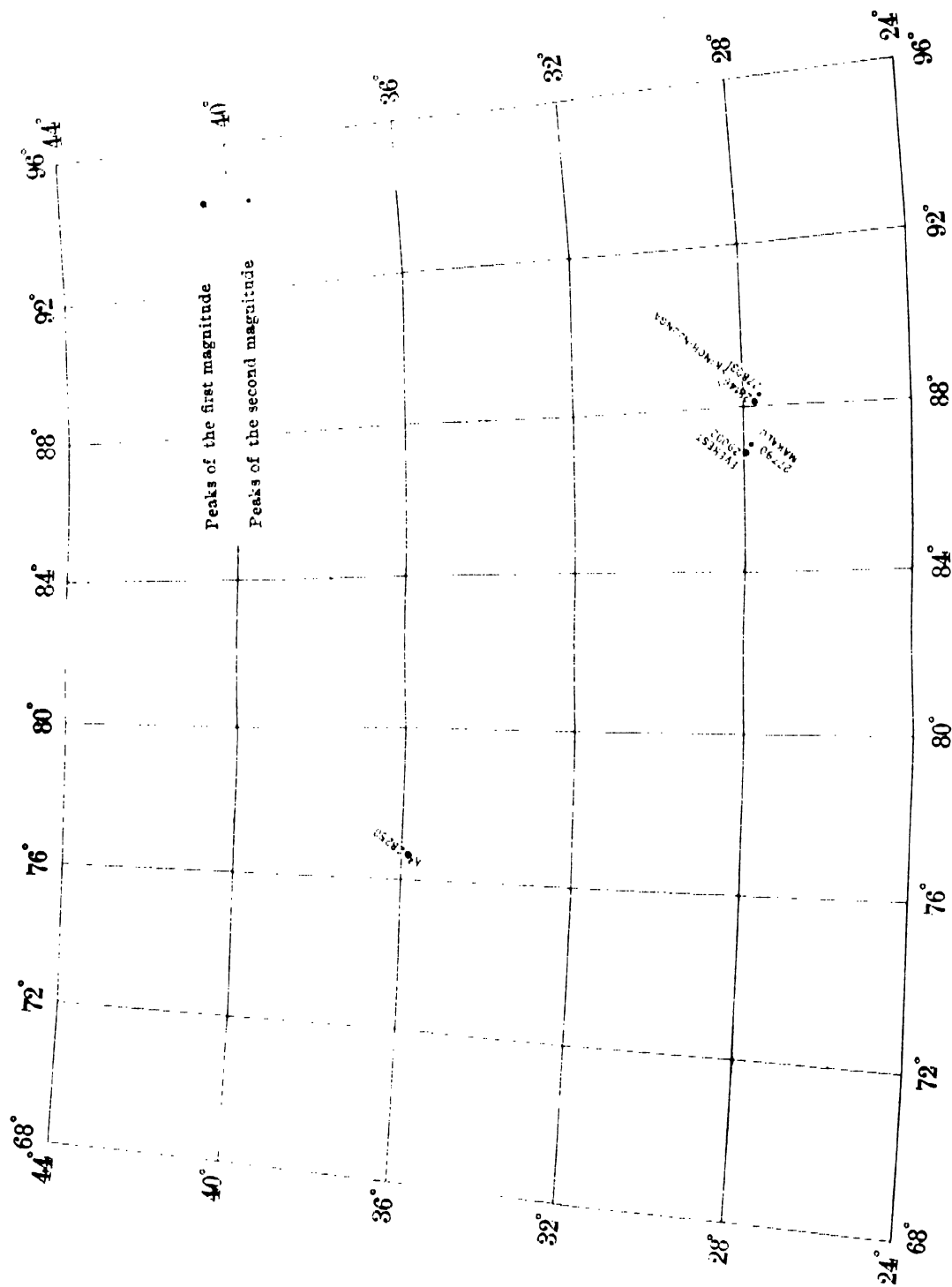
CHART III

PEAKS OF THE THIRD AND HIGHER MAGNITUDES

Peaks of the first magnitude

Peaks of the second magnitude

Peaks of the third magnitude

Nanga Parbat

THE GASHERBRUM PEAKS

Dhaulagiri

No 8

Gosainthan

MAKALU EVEREST

KINCHINJUNGA

CHART IV

PEAKS OF THE FOURTH AND HIGHER MAGNITUDES

Peaks of the first magnitude ●
Peaks of the second magnitude ●
Peaks of the third magnitude ●
Peaks of the fourth magnitude .

CHART V

PEAKS OF THE FIFTH AND HIGHER MAGNITUDES

Peaks of the first magnitude

Peaks of the second magnitude

Peaks of the third magnitude

Peaks of the fourth magnitude

Peaks of the fifth magnitude

Tirich Mir et

Rakapo-h

Astor Parbat

Muztak Ata

On Kwan-Lun Range

Hunza Peaks

Kunjut Peaks

KARAKORAM CLUSTER

No. 52

Shyok Aubru Peaks

On Tian Shan Range

Kamet

Nanda Devi

Gurla Mandhata

On Kven Lun Range

DHAULAGIRI CLUSTER

Gosainthan

EVEREST CLUSTER

KINCHINJUNGA CLUSTER

Kulha Kangri

CHART VI

GAURISANKAR and EVEREST as seen from Mahadeo Pokra in Nepal

19550

(Gaurisankar) 23440

Mount Everest 29002

21980

GAURISANKAR and EVEREST as seen from Kaulia in Nepal
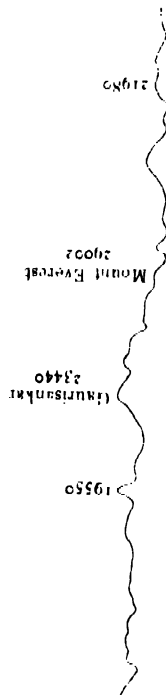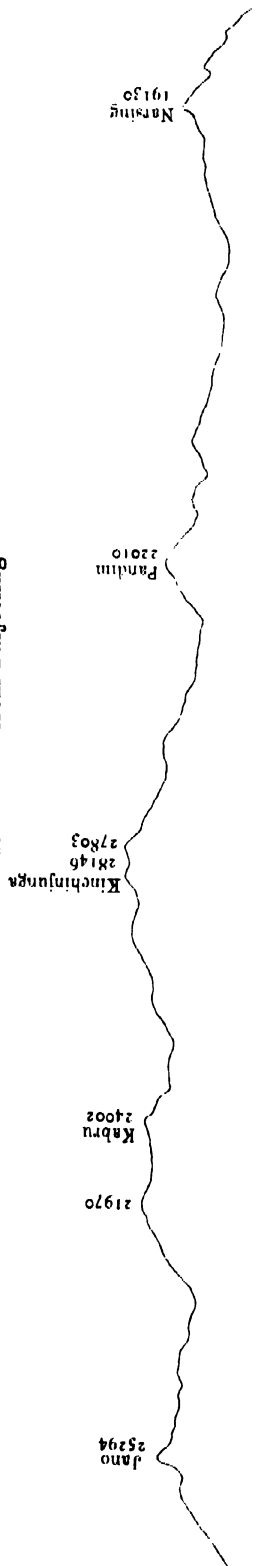
19550

(Gaurisankar) 23440

Mount Everest 29002

21980

KINCHINJUNGA as seen from Darjeeling

Jano 25294

21970

Kabru 24002

Kinchinjunga 28146 27803

Pandim 22010

Narsing 19130

MAKALU and EVEREST as seen from Sandakphu

(Chamlang) 24012

Mount Everest 29002

Makalu 27790

25413
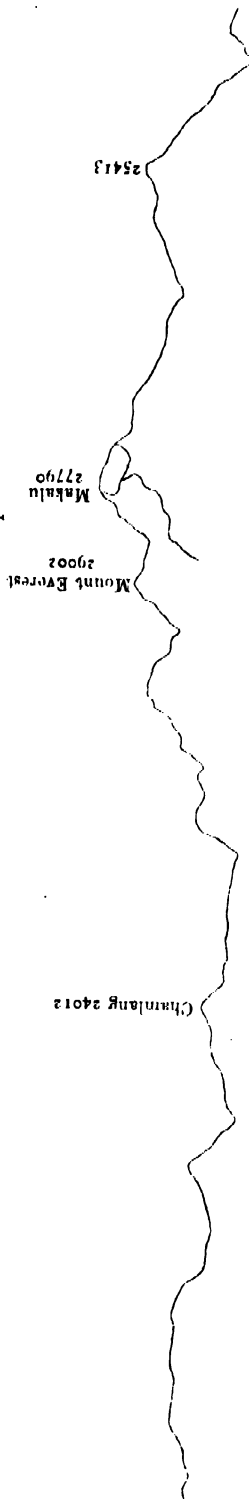
MAKALU and MOUNT EVEREST as seen from Kam-pa Dzong in Tibet

Mount Everest 29002

Makalu 27790

The azimuths and elevations of Mount Everest and Makalu were observed from Kam-pa Dzong by Major Ryder in Season 1903-04
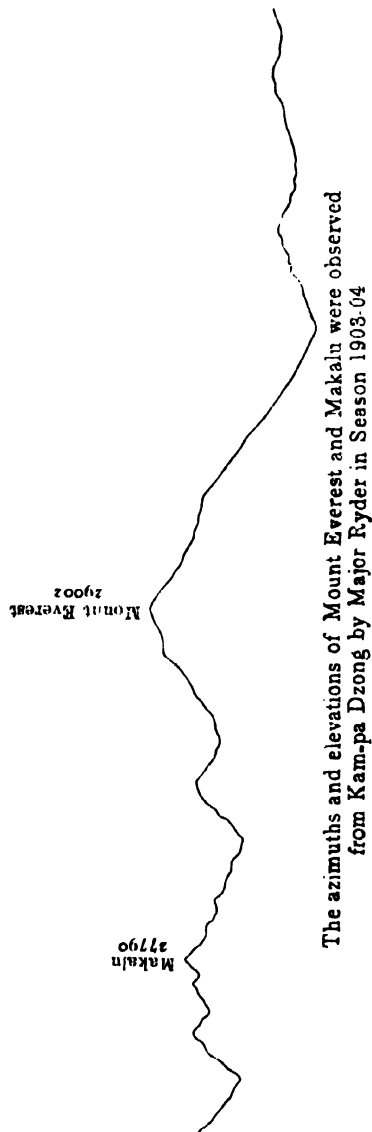
MAKALU and MOUNT EVEREST

as seen by Captain Wood from Pompa-zu-lung (height 18164 feet) in Tibet

Mount Everest 29002

Makalu 27790

W13

CHART VII

OUTLINE of the SNOWY RANGE as seen from Cheena (near Naini Tal)

A

Kamet 25447

Nilkanta 21640

Badrinath 23190

Badrinath 23395

Kharchakund 2161

Kedarnath 22770

B

Nanda Devi 25645

East Trisul 22330

West
Trisul 23360
(Dunagiri hidden
by Trisul)

21286

Mana 23861

A

C

Naulphu 21520

Nandakot 22510

B

Api 23399

Telkot 21114

Panch Chulhi 22650

C

B

---Badrináth 22395

-Badrináth 23190

Daula 19536

23220

----Dunagiri 23184

--- 22516

-- -------Nanda Devi 25645

A

------Srikánta 20120

21890

----21664

----Jaonli 21760

--22628

21594

----Kedárnáth 22770

----Kharchakund 21695

------Satopanth 22388

B

-----Sargaroin 20370

----20560

20014

----Bandarpunch 20720

----19930

A

A SKETCH

OF THE

GEOGRAPHY AND GEOLOGY

OF THE

HIMALAYA MOUNTAINS AND TIBET

BY

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PART II
THE PRINCIPAL MOUNTAIN RANGES OF ASIA

PREFACE

IN 1807 a Survey detachment was deputed by the Surveyor General of Bengal to explore the source of the Ganges: this was the first expedition to the Himalaya undertaken for purely geographical purposes. A hundred years have now elapsed, during which geographical and geological information has been steadily accumulating and we have at length reached a stage where there is danger of losing our way in a maze of unclassified detail: it is therefore desirable to review our present position, to co-ordinate our varied observations and to see how far we have progressed and what directions appear favourable for future lines of advance.

The present paper originated in a proposal submitted by the Survey of India to the Board of Scientific Advice at the meeting of the latter in May 1906. The proposal was as follows:—" The number of travellers in the Himalaya and Tibet is " increasing, and a wider interest is being evinced by the public in the geography of " these regions. It is therefore proposed to compile a paper summarising the geographi- " cal position at the present time."

Subject to the modification that the scope of the paper should be geological as well as geographical, this proposal has received the sanction of the Government of India and the work has been entrusted to us to carry out. On the understanding that the paper is intended primarily for the use of the public, we have endeavoured to avoid purely technical details and to present our results in a popular manner.

Our subject has fallen naturally into four parts, as follows:—

    PART I.—The high peaks of Asia.

    PART II.—The principal mountain ranges of Asia.

    PART III.—The rivers of the Himalaya and Tibet.

    PART IV.—The geology of the Himalaya.

Though the four parts are essentially interdependent, each has been made as far as possible complete in itself and will be published separately. The first three parts are mainly geographical, the fourth part is wholly geological: the parts are subdivided into sections, and against each section in the table of contents is given the name of the author responsible for it.

The endeavour to render each part complete must be our apology for having repeated ourselves in more places than one : the relations, for instance, of a range to a river have been discussed in Part II, when the range was being described, and have been mentioned again in Part III under the account of the river.

As the mountains of Asia become more accurately surveyed, errors will doubtless be found in what we have written and drawn : it is not possible yet to arrive at correct generalisations and we have to be content with first approximations to truth.

Maps, too large for insertion in such a volume as this, are required for a study of the Himalayan mountains : the titles of maps illustrating the text are given in foot-notes and are procurable from the Map Issue Office of the Survey of India in Calcutta. Constable's hand-atlas of India will be found useful.

We are much indebted to Babus Shiv Nath Saha and Ishan Chandra Dev, B.A., for the care with which they have checked our figures and names, and to Mr. J. H. Nichol for the trouble he has taken to ensure the correctness of the charts. Mr. Eccles and Major Lenox Conyngham have been kind enough to examine all proofs, and to give us the benefit of their advice and suggestions. Mr. Eccles has also supervised the drawing and printing of the charts, and we have profited greatly by the interest he has shown in them.

<div align="right">

S. G. BURRARD.

H. H. HAYDEN.

</div>

March 1907.

CONTENTS OF PART II

CHARTS OF PART II.

INDEX.

THE PRINCIPAL MOUNTAIN RANGES OF ASIA.

8

ON THE ORIGIN OF MOUNTAIN RANGES.

THE surface of Central Asia appears to consist of two primary elevations of the crust, separated by a trough-like depression; the southern elevation is the plateau of Tibet, the northern is the Tian Shan chain, the intervening depression is the Tarim basin (see frontispiece, Part I). A second trough is to be seen south of the Tibet plateau, separating that plateau from the ancient Vindhya mountains; it is now filled with alluvium and constitutes the plains of Northern India.

The floor of a former Tibetan sea has been raised and wrinkled.

These two wide elevations of the crust and their complementary depressions form the basis of the mountains of Asia.

Until a comparatively recent date in the geological time-scale—the middle tertiary epoch—all the northern part of what is now the Himalaya, and probably the whole of Tibet were covered by a great sea,* in which deposition of sediment had continued for a vast period. At length, owing to forces, the origin of which we can at present only conjecture, a period of crust-movement set in and the floor of the Tibetan sea began gradually to rise and to be thrown into a series of long parallel wave-like folds.

As the crests of the earth-waves rose from the waters of the sea, they were eroded by rain and weather, and the rising land became broken and irregular: drainage basins were carved out of its flanks and a river system, composed of "transverse" valleys, was gradually developed. As elevation continued, the troughs of the folds emerged and a series of "longitudinal" valleys was established at right angles to the transverse valleys and parallel to the longitudinal axes of the folds. From a combination of the concurrent processes of elevation and erosion, the existing mountain systems of the Himalaya and Tibet have been slowly evolved. As denudation has proceeded, deeper and deeper parts of the crust have been laid bare, but the forms of many folds can still be traced and the trends of their longitudinal axes followed for long distances. The folds, although analogous to waves, more nearly resemble the breakers on a beach than the swell of the open sea; the form of their surface is rarely that of a simple arch and trough; fold has been superimposed on fold, arches have been overturned until they are almost horizontal, and whole areas have been so distorted and crumpled, that the details of structure can only be unravelled with difficulty. Where the stress has exceeded the breaking-strain of rock, the structure has been com-

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* This old sea of a previous geological age once covered much of Europe as well as Central Asia and has been named by Suess the "Tethys," *Natural Science*, Vol. II (1893), p. 183.

plicated by fracture ; parts of the crust have in some cases subsided, and in others been moved horizontally. Nor are these the only causes of complexity, for along many of the planes of weakness and fracture molten material has been forced up from below, and has partly absorbed the original sediments.

Though the origin and nature of the forces which produced the Himalayan mountain system are not subjects which fall within the scope of this paper, it may not be out of place to allude briefly to the more important theories that have been put forward to explain the cause of folding.

The forces that raised the mountains.

The great series of parallel plications in Asia are supposed to have been caused by a horizontal thrust from the north : the sediments of the Eurasian sea were forced against the northern coast of the once continuous Indo-African continental mass which stood like a buttress in the path of the advancing earth-waves. The following hypotheses among others have been advanced to account for the origin of such a thrust :—

(*a*) Contraction of the earth.

(*b*) Disturbance of isostasy.

(*c*) Change in the rate of the earth's rotation.

(*a*) *Contraction of the earth.*—This hypothesis is based on the assumption that the earth as a whole is contracting in volume, owing to loss of heat or other causes, and that the rate of contraction of the inner nucleus is greater than that of the crust ; the latter is thus left unsupported and becomes wrinkled, when adapting itself to its reduced core. Although this theory has met with wide acceptance, it has been adversely criticised by many authorities chiefly on the ground of the inadequacy of any known cause—whether it be gravitation or loss of heat—to produce contraction on a sufficiently large scale to account for the observed folding.*

The extent to which the surface of the earth has been contracted by folding appears to be considerable ; it has, for instance, been calculated that the folds of the Alps represent a contraction of 74 miles, and it has been roughly estimated, that the original surface of Asia has been shortened by wrinkling between Siberia and India by at least 100 miles, and by possibly as much as 400.† Estimates of the contraction of the surface of the earth from the observation of folds are, however, of doubtful value. Even in areas of which the structure is known in greatest detail, the problem cannot be solved by simple measurements, for folds of strata have, in certain cases, been found to indicate stretching rather than contraction, and it is impossible to tell how far the one effect has balanced the other.‡

(*b*) *Disturbance of isostasy.*—This hypothesis was put forward by Captain C. E. Dutton in the year 1889.§ The term " isostasy " may be most suitably explained in

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* *Vide* Rev. O. Fisher's *Physics of the Earth's Crust.*

† In the Sub-Himalaya C. S. Middlemiss found a contraction of 8 miles in 19. *Memoirs, Geological Survey of India,* Vol. XXIV, Part 2, p. 77.

‡ In the Henry Mts., G. K. Gilbert found that a bed of sandstone had been stretched by 300 feet in a distance of three miles. *Report on the Geology of the Henry Mts., U. S. Department of the Interior,* 2nd Edition (1880), p. 75.

§ *Bull. Phil. Soc., Washington,* Vol. XI (1892), pp. 51-64.

Dutton's own words : " If the earth were composed of homogeneous matter its normal
" figure of equilibrium without strain would be a true spheroid of revolution ; but if hetero-
" geneous, if some parts were denser or lighter than others, its normal figure would
" no longer be spheroidal. Where the lighter matter was accumulated there would
" be a tendency to bulge, and where the denser matter existed there would be a tendency
" to flatten or depress the surface. For this condition of equilibrium of figure, to which
" gravitation tends to reduce a planetary body, irrespective of whether it be homo-
" geneous or not, I propose the name *isostasy*. We may also use the corresponding
" adjective *isostatic*. An isostatic earth, composed of homogeneous matter and without
" rotation, would be truly spherical. But if the earth be not homogeneous, if some
" portions near the surface be lighter than others, then the isostatic figure is no longer
" a sphere or spheroid of revolution, but a deformed figure bulged where the matter is
" light and depressed where it is heavy."

The presence in mountain ranges of masses of shallow-water deposits, having
a vertical thickness of many thousand feet, without break of continuity, proves that
during vast periods of time deposition of sediment took place in seas of which the depth
remained constant ; this could only occur if the sea-floor continued to sink *pari passu*
with the deposition of sediment. Observations have also shown that the adjacent land
surfaces, from which the sedimentary material was being taken, were gradually rising
and Captain Dutton was led to conclude * that " these subsidences of accumulated
" deposits and these progressive upward movements of eroded mountain platforms
" are, in the main, results of gravitation restoring the isostasy, which has been disturbed
" by denudation on the one hand and by sedimentation on the other " ; that is to say,
the eroded portion becomes lighter and rises while the loaded area becomes heavier
and sinks, isostatic equilibrium of the crust of the earth being analogous to hydro-
static equilibrium in a fluid. A cause has thus been suggested for the sinking of the
sea-floor on the one hand and the rising of the land on the other ; but in order to
explain the folding of the deposits laid down, it is necessary to take a step further and
assume, as Dutton has done, that as sediment accumulates, the lower layers, owing to
the pressure of the overlying material, acquire a certain amount of plasticity, and that
there is produced " a true viscous flow of the loaded littoral inward upon the unloaded
" continent"; such a process might tend to form long parallel plications following the
trend of the coast-line. The theory of isostasy however does not account for the rise
of the sea-floor and its conversion into a continental mass ; in fact, as enunciated by
Dutton, it tends rather in the opposite direction, and its author expressly stated that
" the theory of isostasy offers no explanation of these permanent changes of level."

So far as the Himalaya are concerned there are grounds for believing that isostasy
is operative and has been an important factor in mountain-building at least during
the later stages of growth of the Siwalik range,† but the hypothesis in its present form

* *Op. Cit.*, p. 56.
† Rev. O. Fisher : *Physics of the Earth's Crust* (1889), and
   C. S. Middlemiss : *Memoirs, Geological Survey of India*, Vol. XXIV, Part 2 (1889).

undoubtedly seems inadequate to account for the uplift of the northern ranges and of the Tibet plateau.

(c) *Change in the rate of the earth's rotation.*—The rate of the earth's rotation was formerly greater than it is now and, as the figure of a rotating body depends on its rate of rotation, any change in the latter will be accompanied by a change in the former. Retardation of the rate of rotation produces a more perfect sphericity, and tends to reduce both the excess of matter at the equator as well as the deficiency at the poles. The strains thus set up might produce a wrinkling of the crust, but can hardly be held to account for the general plication of the surface of the earth.

Other theories have been propounded to explain the origin of mountain ranges, but all are open to objections. Theories, that attribute surface-folds to changes in the position of the earth's axis, cannot be given any weight, for although such changes are known to take place, they have so far been found to be very small.* The theory ascribing the elevation of the sea-floor to the expansion, which it undergoes from heat when it becomes buried under layers of sediment, has been fully discussed and discarded by Middlemiss.†

* Prof. Albrecht: *Astron. Nach,* No. 3619, abstracted in *Nature,* Vol. 58 (1898), p. 42.

† C. S. Middlemiss: *Memoirs, Geological Survey of India,* Vol. XXIV, Part 2 (1890).

9

OBSERVATIONS OF THE PLUMB-LINE AND PENDULUM.

Observations of height cannot be trusted to show the original axial alignment of a mountain range. In the case of a recent range like the Siwalik, the highest peaks do perhaps overlie the axis of elevation, but in the course of years rain and rivers disfigure the original form to such an extent, that when ranges are old, their highest points afford no clue as to the original configuration. Geologists have often found from examinations of the lie of rocks, that a row of peaks, which appears to trigonometrical observers to be a range, marks the line of a former valley, and that the original hills on either side have all been washed away.

Just as geological studies of rocks have upset conclusions derived from surface measurements, so have observations of the plumb-line and pendulum shown that the structure of mountains is more complex and deep-rooted than investigations of surface rocks would lead us to suppose.

A plumb-line, as is explained in Part I, is a string hanging under the influence of gravity. A cord stretched by a hanging weight is forced to assume a vertical position by the attraction of the earth upon the weight, but if a mountain is situated on one side, and a flat plain or deep sea on the other, the plumb-line does not coincide with the normal to the spheroidal surface of the earth but is deflected towards the excess of mass. If the crust of the earth were homogeneous, and if no mountains nor hollows existed at the surface, the plumb-line would everywhere coincide with the normal.*

The earth is so large compared with mountains, that attractions exercised by the latter have but slight influence upon hanging weights, and deflections of the plumb-line are always small. Nevertheless deflections do exist, and by studying them we are able to calculate the excesses and deficiencies of mass hidden in the crust.

In many places in Southern India the plumb-line undoubtedly coincides with the normal, but deflections of 3″ and 4″ are also common. Near Bangalore a deflection of the plumb-line of 7″ towards the south has been discovered; at Deesa one of 8″ towards the north, and at Bombay one of 10″ towards the north. At none of these places are there mountains sufficiently high or near to cause so large deflections of gravity, and the sources of disturbance must be subterranean.†

Between 1830 and 1840, when the trigonometrical survey was first extending its operations across the plains of Northern India, Sir George Everest found that the attraction of the Himalaya mountains was not appreciable, even when they were actually in view. Everest's station of Kaliana near Muzaffarnagar is 40 miles from the outer

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* For definitions of the words *normal* and *vertical* see Part I, footnote to page 24.

† Deflections of the plumb-line are determined from astronomical observations, and are relative to some assumed datum. The values given in this paper are taken from *The intensity and direction of the force of gravity in India, Philosophical Transactions of the Royal Society*, Series A, Vol. 205 (1905).

hills and 120 miles from the line of great peaks, and at this point the plumb-line is only deflected 7″ towards the Himalaya.

In 1852 Archdeacon Pratt of Calcutta calculated what the effect of Himalayan attraction should be at Kaliana according to the laws of gravitation, and he found that the plumb-line there ought to be deflected 27″ towards the north. Seeing how large a deflection was indicated from theory, and how small the actual deflection proved to be, Pratt devised his famous hypothesis of "mountain compensation". He explained the difference between the theoretical and the actual deflection by assuming the mountains to be "compensated". In all parts of the earth's crust, he said, the amount of matter is the same. "In the land portions of the earth's surface," to quote his own words, "there is a deficiency of matter below the sea-level approximately "equal to the amount of matter above it : below ocean beds there is an excess of "matter approximately equal to the deficiency of matter in the ocean as compared "with rocks." Pratt's theory, like the modern theory of isostasy, assumed that mountains were being supported not by the rigidity of the crust but by the buoyancy of light matter floating in a denser medium.

As the operations of the trigonometrical survey have come to be extended to the foot of the Himalaya, it has become increasingly evident, that these mountains are not compensated—at any rate not completely—by underlying deficiencies of density. At the *foot* of the hills north of Kaliana great deflections of the plumb-line have been observed—at Nojli 13″, at Dehra Dun 37″, at Rajpur 47″: at Siliguri in Bengal the deflection is 23″. Throughout the *outer* Himalaya themselves large deflections prevail,— at Kurseong 51″, at Tonglu 42″, at Birond 44″, at Mussooree 37″. These deflections all go to show that the Himalaya mountains must be exercising a more powerful attraction than the observations at Kaliana and other similarly situated places had led Pratt to believe.

The problem that confronted Pratt was,—*Why do the Himalaya exercise no attraction at Kaliana?* The problem that has confronted his successors has been,—*How can the Himalaya exercise a powerful attraction at Dehra Dun, and yet cause but a small deflection at Kaliana, only 55 miles south of Dehra Dun?*

If the attraction of the Himalaya is capable of producing a deflection of 37″ at Dehra Dun, it will produce a deflection of 18″ at Kaliana, and one of 1·5″ at Cape Comorin, the southernmost point of India.* The attraction of a great mountain mass must decrease with distance in accordance with the laws of gravitation, and cannot die suddenly away.

It was suggested by General Walker that the deficiencies of matter underlying the Himalaya were situated so many miles below the surface, that their effect on a plumb-line at Dehra Dun was small and at Kaliana great—that their presence compensated the visible Himalaya when observed from the distance of Kaliana, but not when observed from a near station like Dehra Dun. But this hypothesis did not satisfy mathematical tests ; the actual effects of compensating deficiencies were calculated for a great

many assumed depths, and no depth could be found, at which the deficiency would be compensating for Kaliana and not for Dehra Dun.*

The explanation of the observed phenomena, that is now accepted, is that an invisible chain of excessive density, parallel with the Himalaya, is underlying the plains of northern India: this buried chain is 150 miles distant from the foot of the mountains; at stations like Kaliana the southerly attraction of this chain is counteracting the northerly attraction of the Himalaya; at Dehra Dun, where the Himalaya are near and the buried chain is distant, the effect of the latter is not very apparent, but as we move southwards, the attraction of the visible mountains to the north decreases, and that of the invisible mass to the south increases. The suddenness with which deflections of the plumb-line decrease as we recede from the Himalaya is due to the presence of a southern and subterranean source of opposite attraction.

In 1903 pendulum observations were commenced in India in order to test the correctness of the conclusions that had been drawn from observations of the plumb-line.† The plumb-line shows the direction in which gravity is acting, the pendulum shows the strength with which it pulls. Deflections of the plumb-line are due to the *horizontal* attractions of surrounding masses: observed differences in the strength of gravity are due to variations in the *vertical* attraction of underlying masses.

Observations of the Pendulum.

When a pendulum is being observed, the time in which it makes one vibration has to be measured: if this time is shorter than the normal time, gravity is strong in that locality; if the time is longer than the normal time, it is a proof that gravity is weak. If the force of gravity is found to possess exceptional strength, there must exist an excess of matter in the crust underneath the pendulum station: and if gravity is exceptionally weak there must be subterranean deficiencies of density. Thus the pendulum indicates to what extent the local crust differs from the normal crust in density.

The following tables show the results obtained from pendulum observations during the last three years‡ :—

TABLE XXI—Stations in the Himalaya.

Pendulum station.	Height of station - visible excess of rock.	Invisible deficiency of rock as revealed by the pendulum.	Resultant excess of rock in the crust.
	Feet.	Feet.	Feet.
Kurseong	4915	—3700	+ 1215
Darjeeling	6966	—4070	+ 2896
Sandakphu	11766	—4180	+ 7586
Mussooree (Camel's Back)	6924	—3100	+3824
Mussooree (Dunseverick)	7131	—3270	+ 3861
Simla	7043	—3380	+ 3663

* *Monthly Notices, Royal Astronomical Society,* January 1902, page 183, and *Survey of India. Professional paper No. 5,* 1901.

† *Philosophical Transactions of the Royal Society,* Series A, Vol. 205 (1905).

‡ See Major Lenox Conyngham's reports on the pendulum operations in India, 1903 to 1906.

It will be noticed in the third column that a *deficiency* of rock, averaging 3600 feet, underlies each of the Himalayan stations. The compensation is, however, not complete, and the last column shows the heights at which the stations would be situated, if the crust were everywhere of the same density.

TABLE XXII—Stations near the foot of the Himalaya.

Pendulum station.	Height of station — visible excess of rock.	Invisible deficiency of rock as revealed by the pendulum.	Resultant deficiency of rock in the crust.
	Feet.	Feet.	Feet.
Siliguri	387	—3840	—3453
Dehra Dun	2241	—3440	—1199
Kalka	2202	—2386	— 184
Pathankot	1088	—5055	—3967

The hidden deficiencies underlying these four submontane stations average about 3600 feet; the last column shows, that in every case the subterranean deficiency more than compensates the excess above sea-level, and that on a homogeneous crust the whole submontane region would be situated below sea-level.

TABLE XXIII—Stations between 20 and 30 miles from the Himalaya.

Pendulum station.	Height of station — visible excess of rock.	Invisible deficiency of rock as revealed by the pendulum.	Resultant deficiency of rock in the crust.
	Feet.	Feet.	Feet.
Jalpaiguri	268	—2700	—2432
Ludhiana	833	—1306	— 473

Jalpaiguri of table XXIII is in the plains of Bengal, and 25 miles from Siligur of table XXII : the underlying deficiency of matter has decreased by 1140 feet in those 25 miles.

Ludhiana of table XXIII is in the plains of the Punjab and is more distant from the Himalaya than Pathankot or Kalka of table XXII by 25 miles: the deficiency under Ludhiana is 1080 feet less than under Kalka, and 3749 feet less than under Pathankot.

TABLE XXIV—Stations between 80 and 120 miles from the Himalaya.

Pendulum station.	Height of station -- visible excess of rock.	Invisible excess of rock as revealed by the pendulum.	Resultant excess of rock in the crust.
	Feet.	Feet.	Feet.
Kisnapur	113	+ 1000	+ 1113
Mian Mir	708	+ 170	+ 878
Ferozepore	647	+ 227	+ 874

Kisnapur is in Bengal, Mian Mir and Ferozepore in the Punjab. Below these stations the crust is of excessive density. If the crust were made homogeneous, the stations of table xxiv would all stand higher above sea-level than they do at present.

The pendulum has therefore corroborated the conclusions which were drawn from observations of the plumb-line. In Northern India there are three variations in the crust, where the eye-observer notices but two forms of surface. The eye-observer sees a hilly region on the north and flat plains to the south : the pendulum observer finds three parallel zones--the zone of mountains on the north, the zone of deficiency in the centre, the zone of excess to the south.

From determinations of horizontal attractions the observer of the plumb-line was led to the conclusion that a great chain of density lay buried underneath the plains of northern India, and now the pendulum observer has arrived at the same result from an investigation of vertical attractions.

If when observing near the foot of the Himalaya, we rely upon our eyes or upon our levels, we become aware of mountains on the one side of us but none on the other : but if we disregard the evidence of eye and of level, and believe our pendulums and plumb-lines, we are led to imagine that we are standing between *two* mountain ranges, one of which visible to the north rises abruptly out of the plains, whilst the other invisible to the south slowly gains in elevation for one or two hundreds of miles.

It is not possible to explain how these variations of density in the crust have come about or to what they are due : the parallelism to the Himalaya of the buried chain of density seems to indicate unity of origin, but whether the zones of excess and deficiency are caused by the weight of the Himalaya and of Tibet pressing vertically upon the yielding crust of the earth, or whether by the horizontal thrust of the Himalayan arches against a subterranean abutment, we cannot venture an opinion. It may be that the Himalaya mountains are more due to the buried chain, than the chain is to the Himalaya, and it may be that both mountains and chain have been caused by one and the same movement in the crust.

In reports on geodetic work it is customary to call the outer shell of the earth the *crust*, and in the descriptions given above we have repeatedly referred to the *crust* ; but we possess no evidence that a *crust* exists sharply separated from an interior *core*. It would indeed be more reasonable to assume that the so-called crust and core merge imperceptibly into one another. If, however, the crust of the earth does differ in density from the core, and if the transition from the one to the other is sudden and not gradual, the hidden excesses and deficiencies of mass revealed by the plumb-line and pendulum may be due to variations in the depth, at which the surface of the heavy core lies below the surface of the light crust ; the core may be approaching nearer to the surface of the earth in some places than in others.

Our observations are at present insufficient to admit of the *depth* of the hidden variations of mass being determined, but there are reasons for believing that the excesses and deficiencies, which have been discovered. are between 20 and 70 miles deep.

10

THE HIMALAYA AS REPRESENTED UPON MAPS.

There is no portion of the earth's surface so difficult to represent upon maps

Methods of hill-shading.

as the high mountains of Asia. The complexity of their configuration tries the skill of the most experienced surveyors; and the immensity of their area obliges draftsmen to keep a reserve of power in hand, lest they should reach the utmost possibilities of hill-shading before they have depicted the regions of boldest relief.

In all discussions upon the drawing of mountains the fundamental fact to be recognised is that draftsmen have at their disposal an inadequate means of representation. Hill-shading by strokes of a pen is a feeble method of indicating great variations of slope and height, and the artistic reforms that have been introduced at intervals are evidence of the dissatisfaction of map-makers.

Three different systems of shading by pen strokes have been devised for the representation of mountains on paper, but no one of them can be held to be adequate. Under the first an appearance of relief was given to a map by making eastern and southern slopes dark, western and northern light. Under the second the strongest darks were used for emphasising the greatest altitudes and the commanding points. Under the third depth of shade was made proportional to steepness of slope. In many maps the first and second systems have been combined, in many others the second and third, and in some few there are traces of all three to be found.

In the *General Report of the Survey of India* for 1904-05, the Surveyor General, Colonel Longe, writes: " I believe that no system has yet been evolved by any country " which deals satisfactorily from a systematic and artistic point of view with this " question. If any light can be thrown on this question by any student of the subject " his conclusions would be most gratefully welcomed."

If we examine large scale maps of the Himalaya we become bewildered by the

Methods of generalisation.

ramifications of ridges and spurs, and we fail to discover any evidence of structural law underlying the chaos. If we turn to small scale maps, we find that the mountains have been generalised and are now represented in a simple form. But these generalisations have been carried out by draftsmen, who were unaware of the scientific problems involved, and they are nothing more than conventions.

A draftsman can no more draw mountains without a knowledge of their structure than a landscape artist can draw a village scene without perspective, or than a figure painter can draw men and animals without studying their anatomy. If we attempt to cover many square yards of paper with hill-shading, without having a knowledge of the governing lines of structure, we only succeed in presenting a chaotic mass of incoherent details.

Ruskin says that it is always wrong to draw what we do not see. No one will oppose Ruskin's maxim, but the difficulty in mountains is *to see*, and long experience is necessary to give the power of doing so. The untrained eye will see details readily enough, but it will miss the governing lines. In small scale representations we require the governing lines, not the details.*

In many cases the surveys incorporated in maps have necessarily been executed by eye-sketching from great distances and the mountain features have been roughly delineated. But even when large scale maps do show the hills with accuracy the general effect is apt to be uninteresting and monotonous, and the draftsman, who has to construct from them maps on a smaller scale, is utterly at a loss to know what to retain and what to omit.

Those who realise the difficulties attending generalisation in any branch of science will sympathise with the draftsman who has to discover the governing lines of a mountain mass. A surveyor can map the visible ridges and rivers, but he can never obtain a bird's-eye view of the whole, and in his generalisation he is apt to attach an exaggerated importance to the rivers.

On almost all maps the water-partings are made the most conspicuous ranges:
Undue emphasis is given to water-partings. draftsmen see two streams and create a ridge between them: we thus have ridges running in all directions, the more important the water-parting the darker the ridge. This system has rendered small scale maps useless for scientific investigation. There will be no progress in Himalayan mapping, until the water-parting ridges are subordinated to the ranges of original elevation. The lines of water-parting, though emphasised on maps, have rarely any structural importance, and have but little interest for the geographer or geologist. What, for example, can be more misleading than to show Mount Everest rising from a southern spur of a Tibetan range, because the latter happens to be a water-parting? Yet this was done in the map illustrating the Imperial Gazetteer of India.†

On a map a river is a sharp line, that admits of no modification; a range is indefinite, and can be squeezed at will. On all maps the draftsmen begin by drawing as many rivers as the scale allows, and they adjust the hills afterwards to the rivers.

In nature the mountains determine the directions of rivers: in maps the rivers determine the directions of mountains.

The principal Himalayan rivers tend to flow down *perpendicular* to the great range: this important fact could hardly be illustrated on a large scale map, the details of which would be too intricate; but it should be clearly visible on small scales. When, however, in practice a map comes to be reduced from a large to smaller scales, the

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* The following is extracted from a memorandum on the Survey of Kashmir by Sir Henry Thuillier, Surveyor General of India, who was an expert draftsman : " The difficulty of sketching ground of such a character may be imagined. To do so with any degree of faithfulness requires a peculiar talent and is a gift as much as copying the human face. Stevenson, the civil engineer, in his evidence before parliament on the Ordnance Survey of England stated his belief, that there were not above eight persons in England who understood how to pourtray ground. If difficult therefore in England, it must be still more so, where the relative commands are so immense."—*Journal, Asiatic Society of Bengal*, Vol. XXIX. 1860.

† Dated 1881.

great rivers become nearer together on the paper, and less space is left for the hill-shading between them; in the course of reduction, though numerous ridges have to be eliminated, the great parallel rivers are retained as though they were the governing lines of the topography.   Finally on the smallest scale the draftsman fills up the space between two rivers with a long ridge running *parallel* to them.

Chart x illustrates our meaning: here we have a portion of the Himalaya as re-

Representations of the Kumaun Himalaya. presented on the 1 inch = 32 miles map of India, and the representation has been obtained by generalisation from maps on a larger scale.*   Three rivers, the Sutlej, the Bhagirathi, and the Alaknanda, rise behind the great Himalayan range and cut across it.   These rivers have been allowed to determine the form of the hill-shading on the map, whereas in nature it was the great range that gave to the rivers their falls and determined their directions.

In the first drawing on chart XI the same area is shown as represented on the 1 inch = 64 miles map of India ; the influence of the three rivers upon the hill-shading is very marked.   In the second drawing on chart XI an endeavour has been made to show how the hills should be shaded : the ranges have not been drawn following the rivers, but at right angles to them : the long spurs between the rivers have been eliminated, and the parallelism and continuity of the ranges have been emphasised.

Until the Himalaya have been surveyed by geologists, we shall be limited to drawing conclusions from the forms of the surface.   In studying surface features we must admit as evidence only actual measurements of height and position ; the artistic conventions entered upon maps must be excluded from consideration.   In the drawing of maps on small scales each range must be traced by its peaks, not by its rivers.

If we plot on a chart all the highest points of a region, we find that they align themselves in narrow zones.   This is how the frontispiece of Part I was prepared.   The points of maximum altitude were plotted, and lines drawn through them, the higher the points the thicker the lines were made.   Until geologists prove our assumptions to be wrong, the lines of this frontispiece will be taken to represent the axes of ranges.

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* Kumaun and British Garhwal Survey, Scale 1 inch = 1 mile.

11

THE HODGSONIAN CONTROVERSY.

In 1849 Brian Hodgson, the celebrated naturalist, who was then the political resident
in Nepal, advanced a theory, which has had great influence
upon map-makers, and which is illustrated in chart XII.

Hodgson's views.

The great Himalayan peaks, he maintained, did not stand on a range of mountains, but
on spurs projecting from the Tibetan range behind. Mr. Hodgson devised his theory
to account for two phenomena, *viz.*, (*i*) that the great peaks are not standing on a main
water-parting between India and Tibet, (*ii*) that the Himalayan rivers tend to converge
inside the hills instead of flowing at right angles to the high mountains in a great number
of parallel courses.

"We are led irresistibly to enquire," wrote Mr. Hodgson,* "why the numerous
"large feeders of the rivers, instead of urging their impetuous way from the snows to
"the plains by independent courses, are brought together upon or near the verge of the
"plains : how unity is effected among them despite the interminable maze of ridges they
"traverse, and despite the straight downward impulse given them at their sources.
"I answer, it is because of the superior elevation of the lateral barriers of these river-
"basins, between which there are synclinal slopes of such decided preponderance, that
"they overrule the effect of all other inequalities of surface, how vast soever the latter
"may sometimes be."

"It will be seen by the map (chart XII) that these lateral barriers of the river-basins
"are crowned by the pre-eminent Himalayan peaks, that the peaks themselves have a
"forward position in respect to the *ghât* line or great longitudinal watershed between
"Tibet and India, and that from these stupendous peaks, ridges are sent forth
"southwards proportionally immense."

Mr. Hodgson's views were supported by Sir Joseph Hooker. "The snowy
"mountains seen from the southward," wrote the latter,† "are not on the axis of a
"mountain chain, and do not even indicate its position, but they are lofty
"meridional spurs projecting southwards."

"I have always said," again wrote Sir Joseph Hooker, "that the Sikkim Hima-
"laya (I mean the snowed mountains) do not form a continuous snowed chain running
"east and west, but that they are meridional ridges running north and south, separated
"by waters that flow southerly between them."‡

Mr. Hodgson's arguments can be answered as follows :—the great Himalayan peaks
are not connected by spurs with the Tibetan range, but are separated from it by troughs ;

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* *Journal, Asiatic Society of Bengal,* Vol. XVIII, 1849.
† *Himalayan Journals,* Vol. II, page 298.
‡ *Journal, Royal Geographical Society,* Vol. XX, 1851.

the great peaks are not limited to the ridges between river-basins as drawn by Mr. Hodgson, but stand in a long line which intersects the basins; the Himalayan rivers have not been forced to converge by lofty lateral spurs, but by the recent upheavals of the outer parallel ranges, which have barred the paths of rivers and forced them to combine within the hills.

Mr. Hodgson made the mistake of assuming that the main line of water-parting Undue importance attributed to between India and Tibet must be the main range; in water-partings. Part III of this paper it will be shown that no single range forms this water-parting and that in parts of Tibet the latter even crosses flat plains.

The great Himalayan range has been cut through in places by rivers rising behind it; the rivers were regarded by Hodgson as the fundamental features of the topography and the isolated blocks, into which they had cut the great range, were incorrectly assumed to be spurs of the range behind.

The highest peaks of the Himalaya stand not on spurs but in the crest-zone of a great range; this is the primary fact of structure. The range resembles a crocodile's back; it is a wide flat arch, with relatively slight prominences, called peaks, and it has no sharply edged crest-line. The highest peaks all fall within a narrow zone running throughout the length of the crocodile. Glaciers have cut back between the peaks, and created a serpentine water-parting line along the zone. Many of the great peaks stand actually on the water-parting and many stand off it on either side: but whether they are on the water-parting line or not, they are all situated in the crest-zone of the range.

The great Himalayan range is not the water-parting *between India and Tibet*: streams that flow down the northern slopes of Mount Everest eventually find a passage through a gorge in the range, and join the streams that have their sources on the southern slopes: though this fact prevents the great range from being a continental water-parting, it does not prevent it from being a regional water-parting.

The range which stands behind the great Himalaya, and which was regarded by Hodgson as the Indo-Tibet water-parting, is only a regional water-parting: it separates the streams which flow into the Ganges of Bengal from those which flow into the Brahmaputra of Tibet. But the Brahmaputra and Ganges eventually unite in India, and the water-parting between their upper feeders is no more entitled to be called the water-parting between India and Tibet than the great Himalayan range is.

A range is a wrinkle of the Earth's crust, a water-parting is a line carved by rivers, and though the two coincide during the youth of mountains, they begin to separate when rivers cut the mountains to pieces.

Sir Clements Markham wrote: "A range of mountains is a ridge of elevated land " running in one general direction, and the fact of its being cut through by one or more " rivers does not alter its character and convert it into a series of spurs."[*]

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* Clements R. Markham *on the Himalayan System* in the *Geographical Magazine*, Volume IV, 1877.

Longitudinal troughs separate the Himalayan and Tibetan ranges : and the great

Hodgson generalised from an exceptional case. peaks of Everest, Makalu, Gosainthan and Dhaulagiri are not connected by cross-ridges with the range behind them ; but Kinchinjunga is. Kinchinjunga stands at a point where the Himalayan range assumes an exceptional form, and Kinchinjunga being near to Darjeeling is the peak that Mr. Hodgson knew best, –perhaps the only great peak he had closely observed.

A ridge, well known from the *Himalayan Journals* of Hooker as the Singalila ridge, runs from Tibet through Kinchinjunga southwards to the plains of India, and at right angles to the great range.* This ridge is an extraordinary feature of Himalayan topography ; its crest follows a straight line from Tibet to Bengal ; the descent from the snows to the plains is almost continuous. In Southern Sikkim this ridge is a more marked feature than any continuous snowy range. It is probable that Mr. Hodgson generalised from the Singalila ridge and from Kinchinjunga, and in so doing he generalised from exceptions.†

Mr. Hodgson's theory of Himalayan configuration still finds supporters, and it has

Extensions of Hodgson's theory. been even applied by subsequent writers to other ranges than the Himalaya. Almost all existing small scale maps of Tibet continue to represent the great peaks of the Himalaya as standing on spurs of a hinder range, and it is common to read in geographical works that the highest altitudes of the Karakoram and of the Hindu Kush are to be found not on main ranges but on lateral spurs.‡

The Himalaya have been compared to the Alps, and it has been said that in neither

Comparison with the Alps. region do the highest peaks stand on the water-parting line. But we doubt whether any such comparison is possible. Though many of the high peaks of the Alps may not stand upon what is called the main chain, yet they are all situated within the crest-zone of the range.

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* See North-Eastern Trans-frontier sheet, No. 7 N.W., Scale 1 inch—4 miles. It has been argued that the name Singalila was coined by Hooker, and that no such native name exists. The name has, however, been widely used by geographers following Hooker, and it cannot be abandoned now.

† The transverse ridge of Singalila, separating the basins of the Tista and Kosi, is not a *solitary* exception, for the Narkanda ridge separating the basins of the Sutlej and Jumna, and the Chola ridge, separating the Tista and Raidak, though smaller, are similar. Singalila and Chola are perpendicular to the great range, but Narkanda is oblique. No such continuous ridge separates the basins of the Ganges and Kali, or those of the Ganges and Jumna : the river-basins of the Punjab Himalaya are separated by oblique ranges.

‡ The following is an extract from the narrative of the Survey of Kumaun, vide *General Report of the Survey of India*, 1877-78 :—

" The features of the Nilang valley correspond with the general physical geography of this belt of the Himalaya as observed in other valleys : the main watershed being as a rule lower and the slopes about it easier than the southern and more interrupted range, on which the highest groups of snowy peaks occur. The snowy range is, properly speaking, not a continuous range but a series of enormous spurs which everywhere dominate the parent ridge, the Indian watershed."

The following extract is taken from *Among the Himalayas* by Colonel L. A. Waddell, C.B., C.I.E., 1900 :—

" It was now evident that the Everest range like that of Kinchinjunga seemed off the main axis of the Himalaya and the margin of the great Tibetan plateau, and appeared as a spur and at right angles to that axis."

The following extract is taken from the *Sand-buried ruins of Khotan* by Dr. M. A. Stein, 1904 :—

" The great peak was entirely separated," (from the Kuen Lun), " an interesting observation fully in accord with the orography of the Karakoram and Hindu Kush. There it has long ago been remarked, that the points of greatest elevation are not to be found on the actual watershed but on secondary spurs detached from it."

The case of Mount Everest is quite different: here there are two parallel ranges sixty miles apart, separated by a deep trough; Mount Everest stands on the one, whilst the water-parting is situated on the other. The Alpine peaks and the Alpine water-parting are at any rate upon the same range, but the Himalayan peaks and Himalayan water-parting are not.

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12

THE HIGH PLATEAUX OF ASIA.

The frontispiece of Part I illustrates the position and dimensions of the three high

The horse-shoe. plateaux of Asia. The plateau of Tibet with an average height of 15000 feet is joined at its north-western corner to the Pamir plateau, height 12000 feet, and this again is connected by mountains with the Tian Shan plateau, height 11000 feet. The three plateaux together assume roughly the shape of a horse-shoe.

The want of parallelism between the Tian Shan and Tibet ranges has been supposed to indicate a difference of origin, of age and of elevating force. But no such conclusion is justified from the scanty existing data, and we must for the present regard the three plateaux as one mass. It is not safe to draw too positive conclusions from the directions of ranges, or to assume that a compressing force must have acted in a direction exactly at right angles to the range it has raised; the heterogeneity of the crust may have had an important influence in determining the course of a range. If a portion of the crust, advancing under pressure, meets with hard resistant subterranean masses, the course of the wrinkle will be deflected. Such a mass underlying the Punjab seems to have barred the southward advance of the Himalayan ranges on the west, to have forced the Tibet ranges to converge and to have caused the Karakoram-Hindu Kush range to take the form of a bow.* On the extreme west the Hindu Kush range does assume a significant parallelism with the Tian Shan.

Chart IX has been drawn to illustrate the extraordinary parallelism that exists between the southern border of the Himalaya-Hindu Kush system of mountains on the one side, and the northern border of the ancient mass of rock forming Peninsular India on the other.

The interior of the horse-shoe formed by the plateaux is an inland desert basin (*vide* chart XXII) drained by the Tarim river and its feeders;† the sand of this basin is annually accumulating, and Sven Hedin found towns buried beneath it. The lowest part is the lagoon of Lob Nor (height 2200 feet), and though there is no mountain range closing it on the east, its mouth here is narrow and the desert of Gobi beyond has a superior elevation of nearly 2000 feet. On the north and west and south it is bounded by decomposing mountains, and no other portion of the earth has so gloomy a future. Unless geological changes ensue, the sand will continue to accumulate, until the lagoon of Lob Nor and the rivers of Tarim are choked.

We believe that the plateaux of Asia have been elevated by a horizontal pressure in the crust, and that this has continued to act in a meridional direction through long periods down to the present time. The wrinkling of the crust has taken many forms.

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* The pendulum observations have revealed the presence of a mass of great density underlying the plains of the Punjab.

† Royal Geographical Society's map in Holdich's *Tibet the Mysterious.*

Firstly, there are the great plateaux themselves; secondly, the surfaces of the plateaux have been wrinkled into ranges; and thirdly, the surfaces of the ranges have been corrugated into smaller folds.

The ranges are composed of consolidated rock, but the flat portions of the plateaux,— the only portions in fact which can be described as table-

The flat portions of the plateaux.   lands,*— are troughs between ranges, which have now become filled up with loose débris and boulders, gravel, sand and mud washed down from the mountains and arranged in level layers by water. Ranges vary in breadth, in places bulging towards one another, in places receding from one another, and the intervening troughs and flat plains become alternately narrower and wider.

"The immense extent of the existing alluvium," wrote Henry Strachey,† "and "the uniformity of its maximum elevation lead me to infer that it must have been "deposited under a general sea covering the whole country, and not by lakes, much "less by rivers."

Henry Strachey thought that the alluvium had been deposited at the bottom of an ocean and afterwards upheaved to its present height without the horizontality of its layers being disturbed.

From fossil bones found at a height of 17000 feet in Tibet, Colonel Godwin-Austen drew the conclusion that in recent times the climate which is now arctic must have been sufficiently warm to enable the rhinoceros and other tropical animals to live. "The only rational solution," he wrote, "which science could suggest, was that "within a comparatively modern period, closely trenching upon the time when man "made his appearance upon the face of the earth, the Himalaya has been thrown up "by an increment approaching 8000 or 10000 feet."

It is possible that the action of wind has helped to fill up the high-level basins of the plateaux with loess: this was the suggestion of Baron Von Richthofen. Those of us who have lived in the plains of northern India can testify to the enormous amount of dust carried annually by wind into the mountains. The finer particles of dust are lifted to very high altitudes and are probably transported for hundreds of miles.

Wind may also help to distribute the dust that arises from the decomposing rocks of the plateaux themselves. These rocks are exposed by day to great heat from the direct rays of the sun, and by night to arctic temperatures; and their surfaces rapidly disintegrate under the influence of these changes.

The presence of boulders and gravel proves that the alluvium cannot be wholly attributed to the action of wind, and Sir Martin Conway thinks that mud avalanches have filled up the valleys. "Mud avalanches, I maintain, have done all this work "of filling up the valleys, and done it too with great rapidity."‡

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* Valleys filled to a high level with débris are however not strictly speaking " table-lands."

† Journal, Royal Geographical Society, Volume XXIII. 1853.

‡ Exploration in the Mustagh Mountains, by W. M. Conway in the Geographical Journal, Vol. II, 1893.

The Tibet plateau.

The mountainous area of Tibet extends from the foot of the Siwalik range on the south to the foot of the Kuen Lun range on the north : the alluvial deposits have been washed by rivers out of the greater number of troughs south of the Ladak range and north of the Kuen Lun range, and the principal Tibetan table-lands lie between these two ranges (see frontispiece to Part I). There are however rock basins on the Indian side of the Ladak range that are still filled with alluvium, of which the plains of Nari Khorsam and the valleys of Kashmir, Nepal and Dingri and the several "duns", enclosed by the Siwalik range, are the principal. The extensive plateau of Tsaidam lies north of the Kuen Lun.*

From west to east the Tibet plateau extends from the Karakoram mountains to the Kansu and Ssuchuan provinces of China. Southern Tibet consists of troughs drained by the rivers of India, the Sutlej, the Brahmaputra, the Arun and others. Western Tibet has been compressed between north and south, and its central range, the Karakoram, is the highest. Northern, north-eastern and central Tibet form a table-land which contains vast numbers of lakes. South-eastern Tibet is a rugged mountainous country, and not a table-land : its elevated mass has been cut up by the rivers of China and Burma and is intersected by deep ravines. Tibet is wooded in its south-eastern portion only.

On all sides of the Tibet plateau rivers are cutting back into it by head erosion and the high level alluvial plains are only found intact in those portions which have not as yet been reached by feeders of the oceans. On the north and south and west the great rivers are confined to a few thoroughly drained troughs, and they can only expand their drainage areas now, if their upper feeders succeed in cutting back through the ranges of solid rock bounding the troughs. But on the east the rivers of China rise in the wide troughs of central Tibet and have before them the comparatively easy task of cutting back westwards into the soft alluvium, and of capturing for their basins long zones of the undrained portions of the plateau.

The portions of Tibet drained by the Brahmaputra, the Sutlej, the Indus and the Yarkand rivers are fairly well-known, and chart XXII

The unexplored portions of Tibet. shows that explorers have crossed the plateau in all directions. Nevertheless large areas are still *terræ incognitæ.* Sven Hedin has given us maps of northern Tibet, Prejevalsky of north-eastern, and Deasy of north-western ; but we do not as yet know the positions and heights of the ranges and lakes in the centre of the plateau, nor the westernmost limits of the drainage basins of the Yangtze, Mekong and Salween (frontispiece to Part I).

The narratives of explorers have led us to believe that the interior of Tibet consists of alternate ranges and troughs running east and west, the troughs being partly filled up with alluvium, and containing long series of lakes.

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* Royal Geographical Society's map published in Holdich's *Tibet the Mysterious.*

The plains of western Tibet. In western Tibet the lakes are mostly dry, and flat plains occupy the spaces between the mountains. Of these lofty plains the following are the best known :—

	Area in square miles.	Height in feet.
Nari Khorsam	800	15000
Lingzi Thang	1000	17000
Aksai Chin	1200	16500
Dapsang	500	17500
Deosai	600	12500

These plains hold no water now; Nari Khorsam has long been dry, and having become part of the basin of the Sutlej is now intersected by the deep canyon of that river.*

The plains of Tsaidam consist of salt-wastes and swamps, and form the surface of **The plains of Tsaidam.** the great high-level area, which projects from north-eastern Tibet, and separates the Tarim basin from the desert of Gobi (frontispiece to Part 1). They are situated north of the Kuen Lun range and are consequently not always regarded as part of the Tibet plateau itself. They however belong to the Tibet mountain system, and their exclusion from the plateau is a mere question of definition.

According to Prejevalsky their surface is 1700 feet lower than the level of the water in Koko Nor (height 10700 feet), the principal lake of north-eastern Tibet. The mean height of Tsaidam is consequently about 6000 feet less than that of Tibet.

Prejevalsky described the Tsaidam country as a salt marsh covered with high reeds. Its morasses, he said, were so thickly impregnated with salt as to be encrusted with a layer in some places half an inch to an inch in thickness. The plains of Tsaidam, he thought, were in recent geological times the bed of a large lake.†

Sven Hedin writes that the streams of Tsaidam die away in the sand and that the central parts of the basin are occupied by extensive marshes.‡

The mountains of China are the eastern terminations of the Tibet plateau, and **Eastern limits of Tibet.** belong to the same system of ranges as the Himalaya, the Kuen Lun, and the Karakoram. The provinces of China, that embrace the mountainous area, are Kansu on the north and Ssuchuan on the south. Kansu is in the basin of the Hoang Ho, Ssuchuan in that of the Yangtze, the water-parting between the two being of great altitude. The aridity of Tibet gives place in Kansu and Ssuchuan to a damp climate, and Prejevalsky found that a great increase of moisture occurs in north-east Tibet immediately east of Koko Nor.§

* Nari Khorsam was described in Henry Strachey's paper—*Journal, Royal Geographical Society*, Volume XXIII, 1853 : also in *Memoirs, Geological Survey of India*, Volume XXIII, 1891.

† N. Prejevalsky : *Mongolia*, Volume II, 1876.

‡ Sven Hedin : *Through Asia*.

§ The word *Nor* means *Lake* ; if then we speak of ' *Lake Koko Nor* ' either the word *Lake* or the word *Nor* is redundant, for both have the same meaning. On the other hand the description ' *Lake Koko* ' would not suffice, and ' *Koko Nor* ' would be defective in a popular account. We are therefore of opinion that at the present stage of Tibetan Geography it is desirable to accept the form ' *Lake Koko Nor*.' In the same way we cannot avoid speaking of the ' *Lake of Sir-i-Kul* ' though *Kul* means *Lake* : the ' *Lake of Sir* ' would be insufficient. In England we have the case of Winder-mere and Derwent-water which are frequently spoken of as Lake Winder-mere and Lake Derwent-water. Geographical names, which include both a native word and its English equivalent, such as Lake Koko Nor or Lake Sir-i-Kul, should never be used *upon maps* : in cases, where the native word for lake, or river or pass, has come to be an essential part of the native geographical name, as in Koko Nor and Sir-i-Kul, it is advisable *in the preparation of maps* to adopt the native name without any modification or addition.

The Tian Shan plateau.*

The Tian Shan consists of several ranges crowning a plateau, with alluvial plains in the intervening troughs. The main mass of the plateau south of Issik Kul is 150 miles wide, and 11000 feet high ; the ranges separating the alluvial basins rise to 16000 feet.

The essential difference between the plateaux of Tian Shan and Tibet is that the ranges of the former tend to run in two directions at right angles to one another, whilst those of the latter take but one direction and are generally parallel. " The two " main directions of mountains in the Tian Shan, " writes Prince Kropotkin," are south- " west to north-east (that is, parallel to the fringe of the great plateau of East Asia) and " south-east to north-west which direction is taken by several ranges shooting off the " Tian Shan. The former is the oldest ; the mountains following it have been lifted " up during the palæozoic period, while the other line of upheavals was relatively mod- " ern and attained its greatest force during the tertiary and post-tertiary periods. "†

The Pamir plateau.

The Pamir mass (see frontispiece to Part I) is enclosed in the rectangle formed by tho Hindu Kush, the Kashgar and Trans Alai ranges ; it is the water-parting between two inland systems of drainage,‡ one of which ends in the sea of Aral, the other in the lagoons of Lob Nor. Its elevated plains, like those of Tibet and Tian Shan, consist of horizontal accumulations of gravel deposited in rocky troughs.

The ranges enclosing the alluvial troughs of Tibet are parallel to one another, and **The structure of the Pamir plateau.** those of the Tian Shan are according to Kropotkin mutually perpendicular ; the directions of the Pamir ranges have not yet been determined. We do not know how the Kashgar and Sarikol ranges connect with the Tian Shan (see frontispiece to Part I), nor how the crustal folds of the Pamir plateau trend west of the Sarikol range. We can form some idea as to the direction of the force which elevated Tibet and the Tian Shan into wrinkles, but the Pamir presents a more difficult problem, which cannot be solved from existing data.

Humboldt's conception of the Pamir was a great meridional range connecting the Tibetan and Tian Shan systems, and this view was supported subsequently by Hayward : but Severtsoff and Fedchenko contended that the fundamental mass of the Pamir plateau was a series of parallel ranges running from east to west. From the plains of Kashgar Hayward saw a snowy range on the east of the Pamir running north and south : Fedchenko argued that this so-called range consisted only of the ends of the parallel ranges which were running east and west.

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* See *The Central Tian-Shan Mountains*, 1905, by Merzbacher. An excellent account of the Tian Shan plateau was given by Ellsworth Huntington in the *Geographical Journal* for January 1905.

† *Geographical Journal*, Vol. XXIII, 1904.

‡ Northern Trans-frontier Sheet No. 2 : scale 1 inch=8 miles.

We know now that two ranges, the Kashgar and the Sarikol, separated by a high level trough, do trend not exactly meridionally but from north-west to south-east, and these ranges form the eastern portion of the Pamir mass.

The frontispiece to Part I shows these ranges to be connected with the north-western ranges of Tibet. That the Kashgar range is a continuation of the Kuen Lun is considered certain, but the connection of the Sarikol range on the chart with the Aghil is nothing more than conjecture. We cannot even conjecture how the Kashgar and Sarikol ranges are connected with the Tian Shan.

As to the structure of the Pamir mass west of the Sarikol range, there undoubtedly exists a series of parallel valleys running east and west and separated by mountain chains. But we do not know whether these east and west chains are real original ranges wrinkled at right angles to the Sarikol and Kashgar ranges, or whether they are long spurs of the Sarikol range carved by water. If the latter view is correct then the whole Pamir plateau is a broad fold of the crust sloping steeply on the east, gently on the west, and running north and south. Whatever may have been the direction in which the principal force of upheaval acted, complicated cross-pressures from different sides have probably contributed to form the elevated mass that is now standing at the conjunction of the Tibetan and Tian Shan systems.

The configuration of the Pamir plateau. The average elevation of the Pamir alluvial plains is 12000 feet, and that of the mountains dividing them 17000 feet.

"Pamir," wrote Stoliczka, "is not a plateau at all : it is a congregation of chains."[*]

"We may say," wrote Sven Hedin, "that the Pamir may be grouped into two sharply " contrasted divisions, an eastern half which is principally a plateau land such as I have " described, and a western half consisting of latitudinal mountain chains disposed parallel " to each other. There can be no doubt that at one period the entire region was strictly a " plateau and that it is being rapidly broken down by the agency of erosion."[†]

" The meridional range," wrote Colonel Wahab, " forms the eastern boundary of the " Pamir plateau ; that range and the Hindu Kush are the dominating features of the " region ; the trend of the several ranges which are being carved out of the original plateau " is parallel to the Hindu Kush. There is nothing on the west that can be called a " meridional chain, though the course of the Oxus is deflected in that direction by a great " spur thrown out from the Hindu Kush north of Tirich Mir."[‡]

" Beyond the fact," wrote Lord Curzon, " that the general elevation of the Pamir " valleys is from 12000 to 14000 feet, and that they are consequently at a higher level than " the surrounding countries, there is nothing in their superficial character in the least " degree calculated to suggest a table-land or plateau, which I take to mean a broad " stretch of flat and elevated land, surrounded, may be, and even interspersed, but not " positively broken up, with mountain masses. Nor can anything less like a down or a

* Suess : *Das antlitz der Erde*.
† Sven Hedin: *Through Asia*, page 185.
‡ Extract from a letter.

" steppe be conceived than the troughs or valleys, of no great width, shelving down-
" wards to a river-bed or lake, and uniformly framed on either hand by mountains,
" whose heads are perpetually covered with snow, which anybody who has been to the
" Pamirs will at once recognize as a fair description of those regions. In reality, over
" the entire region embraced by the title, it has been calculated that the plains or valleys
" constitute less than one-tenth of the total area. Correctly described, a Pamir in theory,
" and each Pamir in fact, is therefore neither a plain, nor a down, nor a steppe, nor a
" plateau, but a mountain valley of glacial formation, differing only from the adjacent or
" other mountain valleys in its superior altitude, and in the greater degree to which its
" trough has been filled up by glacial detritus and alluvium, and has thereby
" approximated in appearance to a plain owing to the inability of the central stream to
" scour for itself a deeper channel."*

Lord Curzon enumerates eight Pamirs or alluvial plains :—

(i) The Taghdumbash Pamir lies in the basin of the Tarim, and north-east of the Kilik pass ; it is 60 miles long and from one to five miles broad ; it is drained by the Tashkurgan, a feeder of the Yarkand river.

(ii) The Wakhan Pamir extends for 20 miles along the northern bank of the Wak-han affluent of the Oxus.

(iii) The Little Pamir encloses lake Chakmaktin and follows the Aksu affluent of the Oxus for 60 miles. It is a long grassy plain varying from one to four miles in breadth.

(iv) The Great Pamir encloses the lake of Sir-i-Kul ; it is 80 miles long and varies in width from one to six miles ; it is in the basin of the Oxus.

(v) The Alichur Pamir lies north of the Great Pamir and is in the basin of the Oxus. It contains the lake of Yeshil Kul.

(vi) The Sarez Pamir is north of the Alichur Pamir and in the basin of the Oxus.

(vii) The Rang Kul Pamir containing the lake of that name lies north-east of the Sarez Pamir ; it possesses no drainage outlet.

(viii) The Khargosh Pamir is north of the Sarez Pamir and encloses the great Kara Kul lake ; it possesses no drainage outlet.

* *Geographical Journal,* Vol. VIII, 1896.

13

THE PRINCIPAL MOUNTAIN RANGES OF ASIA.

The plateaux have been wrinkled into ranges, and the intervening troughs have been filled with débris and their surfaces levelled by the action of water : one of the first tasks now confronting geographers and geologists is the investigation of the ranges,—the determination of their positions, heights and trends.

Although large portions of the earth's surface have been surveyed and examined, the origin of mountains is not as yet understood ; various explanations have been offered but none has been generally accepted. Geologists and physicists and mathematicians differ in their views, and the problems arising from the wrinkling of the earth's surface must still be regarded as unsolved. Complete surveys of the Himalaya will afford valuable data, provided we realise at the outset the questions involved. We must not confuse *ranges* and *ridges*; *ranges*, however modified by denudation, are features of original structure; *ridges* are the results of erosion only. *Ranges*, as their name denotes, must possess length, and an elevated ring or dome or compact mass could not be called a *range*. But though length is an essential feature of a true *range*, a long line of mountains is not necessarily a *range*, for it may have been carved by rain and rivers out of an older and larger mass.

Surveyors and geologists will have to determine in the field how the several Tibetan ranges run, and whether they are connected by cross-ranges or not ; they will have to discover to what extent the form and structure of the Himalaya resemble those of the Andes and Alps ; they will have to enter upon the investigation with open minds, and endeavour to learn, without preconception or bias, how the Tibetan and Himalayan ranges have been upraised.

The ranges of Central Asia appear all to belong to one great system, and to have no separate existence apart from that system, and no investigations are likely to be profitable that leave out of account the relations of the ranges to one another. "The "physical unity." wrote Richard Strachey, " of the great mass of Tibet with the "Himalaya range seems to me very strongly shown by the general geological "structure." The parallelism of the Kailas, the Ladak, the Great and Lesser Himalaya and the Siwalik ranges, all of which change direction together, is evidence of interconnection.

The high ranges of Asia—those that are known to us—may be classified as follows :—

I. **Ranges of the first magnitude, carrying many peaks above 25000 feet—**
      (1) The Great Himalaya in Nepal.
      (2) The Karakoram.

II. *Ranges of the second magnitude, carrying many peaks above* 22000 *feet—*
   (1) The Great Himalaya in Kumaun.
   (2) The Hindu Kush.
   (3) The Kuen Lun.
   (4) The Kashgar range.

III. *Ranges of the third magnitude, carrying many peaks above* 19000 *feet—*
   (1) The Great Himalaya in Assam.
   (2) The Great Himalaya in the Punjab.
   (3) The Ladak range.
   (4) The Kailas range.
   (5) The Tian Shan.
   (6) The Trans Alai range.
   (7) The Zaskar range.
   (8) The Aghil range.
   (9) The Ninchinthangla range.

IV. *Ranges of the fourth magnitude, carrying many peaks above* 15000 *feet—*
   (1) The Sarikol range.
   (2) The Alai range.
   (3) Eastern portion of the Pir Panjal range of the Lesser Himalaya.
   (4) Eastern portion of the Dhauladhar range of the Lesser Himalaya.

V. *Ranges of the fifth magnitude, carrying many peaks above* 11000 *feet—*
   (1) Western portion of the Pir Panjal range of the Lesser Himalaya.
   (2) The North Kashmir range of the Lesser Himalaya.

VI. *Ranges of the sixth magnitude, carrying peaks above* 7000 *feet—*
   (1) Western portion of the Dhauladhar range of the Lesser Himalaya.
   (2) The Nag Tibba range of the Lesser Himalaya.
   (3) The Mussooree range of the Lesser Himalaya.
   (4) The Mahabarat range of the Lesser Himalaya.
   (5) The Rattan Pir range of the Lesser Himalaya.

VII. *Range of the seventh magnitude, carrying peaks above* 3000 *feet—*
   (1) The Siwalik range.

It has been argued that the Great Himalaya range is the " border range " of the plateau of Tibet, and comparisons have been drawn with other mountainous regions in which the highest range forms the border. But the frontispiece to Part I shows that the real " border range " on the south of the mountains of Asia is not the Great Himalaya but the low Siwalik.

Our geographical knowledge is not at present sufficiently complete to enable us to show on a map all the principal ranges of High Asia, and breaks in the lines of the frontispiece chart have been introduced where information is altogether wanting. British surveyors have observed

Geographical knowledge incomplete.

the high peaks of the Himalaya, of the Karakoram, of the Hindu Kush, of the Ladak and of the Kailas ranges. Russian surveyors have fixed the principal points of the Tian Shan. But observations of the Kuen Lun have been limited to their western end ; those of the Sarikol and Kashgar ranges are deficient in accuracy and completeness, and our knowledge of the Aghil range and of all the ranges of central and eastern Tibet is at present based not on trigonometrical determinations but on the reports of travellers.

It is possible that many of our present ideas of ranges will be found in the future to be incorrect : geographical science when it is not advanced by sound and systematic surveys, but is dependent on the information acquired from the itineraries of explorers, has to make its way by zig-zags of approach, often overshooting the mark to which it is directed, sometimes perhaps going wrong altogether, but yet always endeavouring to reach its goal by successive approximations.* Until all data, that are based upon the writings of travellers and upon the cross-examinations of natives, have been superseded by the results of a rigorous survey, the geography of central, of northern and of eastern Tibet will have to be regarded as a preliminary approximation, which is liable to be largely corrected in future.

We do not as yet know the number of great ranges that cross Tibet from west to east : one explorer follows a trough between two ranges and another does the same along a parallel line to the south, but without trigonometrical determinations of the positions of peaks we cannot tell if the range seen to the south by the northern traveller is identical with that seen to the north by the southern traveller.

We do not know whether the Karakoram range ramifies in its eastern extension over central Tibet, nor how the Tibetan ranges merge into the oblique and diverging chains of Ssuchuan and Burma, nor how the Kuen Lun range breaks up at its eastern extremity into the complicated network of minor ranges, described by Prejevalsky and Sven Hedin.

It is certain that great parallel ranges do traverse Tibet from west to east and that after being compressed between Peshawar and Yarkand they tend to diverge as they progress eastwards. In northern Tibet Sven Hedin followed a trough running east and west between two ranges for 400 miles, Wellby explored a similar trough and Nain Singh traversed one of great length in central Tibet.

It is open to question whether we are justified in drawing the Kailas, the Ladak, the Great Himalaya and the Siwalik ranges, on the frontispiece of Part I, continuous throughout their whole lengths. By giving them an uninterrupted continuity we imply that each range is a separate wrinkle of the crust, raised throughout its length, not necessarily at the same time, but by the same series of movements. It is possible that these ranges will be found in places to cease and to consist in reality of two or more shorter ranges, differing perhaps

Continuity of ranges.

* See General Walker's notes on his map of Turkistan, which he compiled in the office of the Trigonometrical Survey at Dehra Dun in 1873.

slightly in alignment and overlapping each other at their extremities.   Observations of peaks, however, lead us to believe that the ranges are continuous and are not broken by overlaps.

In the Great Himalayan range continuity of alignment has been almost established throughout.   It is difficult certainly to trace the prolongation of the Kumaun Himalaya into the Punjab, the Sutlej having cut through and destroyed all signs of the original connection (figure 4, chart XVI), but the evidence available tends to indicate that the Kumaun and Punjab Himalaya were once a continuous range, and there are no signs of the existence of any original overlap.   The only overlap that we know of is one on the Siwalik range illustrated in figure 2 of chart XIX, and this occupies such a narrow area, that if the range ever grows into a broad high fold, the overlap will be lifted up and become a mere surface feature of the crest.

From what has been said, it will be readily understood that no complete representa-

The chart of ranges in Part I.

tion of the principal ranges of Asia can at present be prepared.   Between perfect knowledge and entire ignorance there lies a wide field of uncertain information derived from inferences and speculations ; it is not possible to omit all unverified information ; were we to do so, our chart would be almost a blank.   For the aid of future investigators we must include theories and ideas which may be confirmed or may be disproved hereafter.   In the descriptions of individual ranges, however, care has been taken to distinguish between what is known and what is inferred.

Though the range-chart of Part I may be found in the future to contain errors, it summarises the present position of Himalayan geography.   No attempt has been made to show the spans of the ranges nor the numberless subsidiary ridges into which the ranges have been carved by water; we have merely indicated the trends of the original axes of elevation, and, in order to give some idea of the relative magnitudes of the ranges, we have thickened the alignments that carry the highest peaks, and drawn those of low elevation finely.

14

THE RANGES OF THE HIMALAYA.

The ranges of the Himalaya may be classified as follows (*vide* frontispiece 'of Part I):—

(I) The Great Himalaya, a single range rising above the limits of perpetual snow.

(II) The Lesser Himalaya, a series of ranges closely related to the great range.

(III) The Siwalik ranges, which intervene between the Lesser Himalaya and the plains.

The Great Himalaya range.

The Himalaya is the name applied to the intricate and complex system of mountains that forms the northern boundary of India from Afghanistan to Burma. Some writers have limited the name *Himalaya* to the mountain ranges included between the Indus and the Brahmaputra, but any such limitation conveys an erroneous idea of the physical unity of the mass. The Indus and the Brahmaputra, like the Sutlej and the Ganges, cut across the Himalaya through gorges, which they themselves have carved, and one of the problems now confronting geographers and geologists is the determination of the trans-Indus and trans-Brahmaputra courses of the Himalayan ranges. We shall not therefore be in a position to define the limits of the Himalaya, until the geology of their extremities has been studied.

The Great and Lesser Himalaya and the Siwalik ranges are so closely related

The Himalayan area divided into five parallel zones.

that it may perhaps be desirable to commence with a general description of the area they cover. The outer zone of mountains, which is contiguous to the plains of India and which contains the small Siwalik range and the valleys in rear of it, was elevated more recently than the Himalaya : the width of this zone varies from five to thirty miles, being narrow in those places where the Siwalik range is jammed against the Lesser Himalaya, and wide where open valleys intervene.

The second zone is 40 or 50 miles broad, and is covered with mountains, that assume in the Punjab and Nepal the form of longitudinal ranges running generally parallel to the great range. In Kumaun the form is more intricate : here the peaks of the second zone do not appear to follow distinct alignments of maximum elevation, but to be scattered throughout the region and to possess everywhere a remarkable uniformity of height between 6000 and 10000 feet.

The third zone is 10 miles broad, and is occupied by spurs projecting southwards from the great range ; a few peaks of this zone exceed 15000 feet in height.

The fourth zone is 15 miles broad, and contains the great line of snowy peaks, the average height of which exceeds 20000 feet. With the exception of the low

ravines cut by rivers, the whole of this zone is situated above the limits of perpetual snow. To an observer on the outer hills the Lesser Himalaya appear to vary but slightly in altitude throughout a great area, but the Great Himalaya range to the north seems to rise suddenly like a wall of snow.

The fifth zone is about 25 miles broad, and contains the troughs of rivers rising behind the Great Himalaya. The average height of the beds of the troughs is 14000 feet and of the mountains intersecting them 19000 feet; the average height of the zone is considerably less than that of the snowy zone.

The ranges covered with perpetual snow and the highest altitudes of the Himalaya occur about 90 miles from the southern limit of the mountains.

In the charts XIV and XV eight cross-sections are shown; they have been drawn through the Himalaya at different points but always at right angles to the great range.

The rocks of the Siwalik range are stratified and date from the latter half of the
The age of the Himalaya. tertiary period; those of the outer Himalaya are stratified also but are very much older.

The central axis of the Great Himalayan range is composed of granite and gneiss; on either side of it are to be seen immense depths of sedimentary strata, which show that thousands of feet of rock have been removed from the crest-line. The granite solidified and cooled while below the surface of the earth, and its original covering has been worn away by the subsequent action of seas and rivers.

The Great Himalaya rose to be a mountain range in the same geological age as the mountains of Afghanistan and Baluchistan on the west and as those of Arakan and Manipur on the east.* The immense depression of northern India, now filled with the alluvium of the Ganges and Indus, dates from the same period as the elevation of the Himalaya; as the latter was pressed upwards into an arch, the former was pressed downwards into a trough.

Though the whole length of the Great Himalaya range belongs to one geological age, yet the Punjab Himalaya are supposed to have risen at a somewhat later date than the Nepal Himalaya. The presence at elevations of 16000 feet in the Punjab Himalaya of nummulites indicates that this portion of the range did not emerge from the sea till comparatively recently.

The direction of the Great Himalaya range does not bend with an uniform cur-
Bifurcations. vature, but follows different alignments. As it bends from west to north-west it frequently bifurcates and throws off minor ranges on the convex side of the bends. At each bifurcation the minor range tends at first to continue in the alignment which the great range is forsaking; it gradually, however, turns and finally runs parallel to the new alignment of the great range.

For purposes of description it is convenient to divide the great range into four
The total length of the Himalaya divided into four sections. parts,—the Assam Himalaya, the Nepal Himalaya, the Kumaun Himalaya, and the Punjab Himalaya. Whilst

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* A Manual of the Geology of India. 2nd Edition, page 494.

in all four parts the great range rises like a wall and the outer ranges tend to run parallel to it, no one portion of the Himalaya resembles another. In Sikkim the lesser and outer ranges are absent; in Kashmir they are conspicuous; in Kumaun they exist, but being oblique in their trend are not clearly marked. Sikkim is a transverse basin, Kashmir is a longitudinal basin, Kumaun is an intricate region of mountains.

In Nepal we find numerous rivers cutting across the Great Himalaya range; in the Punjab between the Sutlej and the Indus we do not find one. In Nepal the great peaks stand in clusters and rows; the great peak of the Punjab stands in solitude.

The differences between different Himalayan regions show how impossible it is to deduce general laws from the study of one area.

The Assam Himalaya extend from the Brahmaputra to the Tista. Their highest peaks are Kulha Kangri (table v, Part I). The **The Assam Himalaya.** axis of the range appears to trend from east to slgihtly south of west; it meets the Nepal section of the range in Sikkim, and at the conjunction a change of alignment takes place, the great range in Nepal trending from east to north of west.

At the point where the change occurs, a remarkable sinuosity in the main range is observable; the lower and outer ranges moreover disappear and two long spurs stretch southwards to the plains,—the Singalila ridge from Kinchinjunga and the Chola ridge from Pauhunri.* It is conceivable that the change of alignment, the sinuosity of axis, the disappearance of the outer ranges and the two great ridges are all effects of an easterly pressure from the direction of Burma along the range.

The Nepal Himalaya stretch from the Tista to the Kali, and carry the peaks of Everest, Kinchinjunga, Makalu and Dhaulagiri. The great **The Nepal Himalaya.** range bends and bifurcates near Dhaulagiri (see figure 1, chart xvi). West of Dhaulagiri (26795 feet) the height of the range diminishes and throughout the wide basin of the Karnali the highest peaks do not rise above 22000 feet; near the western edge of the basin there is the Api-Nampa cluster of peaks.

Not far from Nampa there is a second bifurcation of the great range (figure 2, chart xvi). At all the other Himalayan bifurcations the more northerly branch has been regarded as the continuation of the great range, but from Nampa the southerly branch, carrying Nanda Devi (25645 feet) and Badrinath (23190 feet) has been assumed to be the Great Himalaya, and the northerly branch carrying Kamet (25447 feet) and Leo Pargial (22210 feet) to be the Zaskar range.† After the Nampa bifurcation the southern branch is so large and carries such high peaks, that the northern is obscured from view from the side of India: but at all other bifurcations the northern branch remains the more important, and the more remarkable to Indian observers. *Himalaya was the name given by the Hindus to the snowy range visible from India.*

* North-East Transfrontier sheet No. 7 N. W., 1 inch=4 miles.
† Kamet is seventeen miles in rear of Badrinath, the Vishnuganga flowing between. Atlas Sheets 65 and 66; Scale I inch=4 miles.

The Kumaun Himalaya stretch from the Kali to the Sutlej; the highest peak
The Kumaun Himalaya.   is Nanda Devi (25645 feet). There are bifurcations at Bad-
rinath and at the Sutlej (see chart xvi).

After the bifurcation at Nampa the width of the great range becomes less and
its altitude greater; after the bifurcation at Badrinath (see figure 3, chart xvi) the
width becomes greater and the altitude less.

The upper surface of the Kumaun Himalaya appears to be corrugated. The
Gangotri glacier, for example, at the source of the Bhagirathi flows for 16 miles along
a trough in the crest-zone of the great range (see chart xxiv, Part III). The mean
altitude of its surface is 14000 feet, and there are peaks of 22000 feet on either side
within 2 miles of it; its trough is parallel to the axis of the great range. * Similar
corrugations exist in the Nepal Himalaya behind Mount Everest.† The parallelism
of the corrugations leads us to think that they are the results of a superficial compression
of the crust. The view of the Great Himalaya, that is obtainable from the plains
of India or from the outer hills, conveys the impression that the snowy range
possesses a narrow and sharply-edged crest-line, but this idea is incorrect: the summit
of the range is several miles broad, and the great peaks stand in a wide zone. To a
distant observer the snowy range east of the Sutlej appears to resemble the edge of a
saw, but its crest-zone measures 30 miles in breadth.

The Kumaun and the Punjab Himalaya do not follow the same alignment, and
The Punjab Himalaya.   originally met at an angle; they are now separated
by the defile of the Sutlej, which cuts across the range
exactly at the angle. An important bifurcation occurs here (figure 4, chart xvi).
After the bifurcation at Dhaulagiri the elevation of the range diminishes, and a
similar diminution occurs after the bifurcation at the Sutlej. East of Dhaulagiri
there are peaks exceeding 26000 feet, west of it but few peaks rise to 22000 feet.
East of the Sutlej the Kedarnath, Jaonli and Badrinath peaks stand above 22000 feet,
but west of the Sutlej few peaks exceed 20000 feet. We have already seen that as
a range bends, it bifurcates, and now we see that it changes its form after bifurcation.

The characteristics of the great range are so different on the two sides of the
Sutlej that doubts as to its original continuity have been expressed: our maps show
one range meeting the Sutlej from the east, and two, if not three, smaller ranges
leaving it on the west.

The difficulty of determining he original lines of structure is increased by the
presence of the extraordinary Narkanda-Mahasu ridge that runs diagonally
across the Himalaya from the high snows to the low plains :‡ this ridge is not cut across
by any river, and its unbroken uniformity of descent is only equalled by that of
Singalila. It forms the southern boundary of the basin of the Sutlej, and it was

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* Atlas Sheet No. 65 : 1 inch = 4 miles.
† Map of Nepal, 1 inch = 16 miles.
‡ See Atlas Sheet No. 47, scale 1 inch = 4 miles, and Sheets of the Punjab Survey. Nos. 310 S.-E. and 311 N.-E.,
Scale 1 inch = half-a-mile.

regarded by Mr. Fraser in 1820, by Captain Herbert in 1821, and by Captain Gerard in 1822 as the real termination of the great Himalaya of Kumaun and Nepal.

The bifurcating branch at Badrinath becomes the Dhauladhar range of the lesser Himalaya, that at the Sutlej becomes the Pir Panjal range of Kashmir. The Dhauladhar, the Pir Panjal, the Punjab Himalaya and the Zaskar ranges are all secondary undulations superposed on one flat broad arch, the span of which reaches from the plains of the Punjab to the Indus in Tibet.

Near the centre of the Punjab Himalaya the range culminates in the Nun Kun peaks* (23410 and 23250 feet) which stand 3000 feet above the crest.

The water-parting of the Punjab Himalaya follows an exceptionally straight line from the Sutlej to the Nun Kun peaks, and again from those peaks onwards, but at the peaks themselves it exhibits a double sinuosity, which is illustrated on chart xxxiv of Part III, and which is possibly a feature of original structure. North-west of the Nun Kun peaks the crest-zone is in places corrugated.

The northern and southern slopes of the Punjab Himalaya are very different in form and character; the northern are bare and stony, but contain lakes and high plains, the southern are forest-clad but are seldom level.

In the Nepal and Kumaun Himalaya there are many river gorges piercing the granite range, but no river crosses the Punjab Himalaya. The Zoji pass, however, is a remarkable feature of the latter. This pass across the great range is only 11300 feet high, and is consequently below the level of the troughs that lie in rear of the Nepal Himalaya. "Such a depression elsewhere would have been sufficiently deep to open "a passage for the drainage of the table-land, but the great depth of the valley further "north, in which the Indus flows, here gives the waters a more favourable escape in that "direction."†

Though the Zoji defile was probably carved out of the range by a pre-historic river, it is now a true pass, that is to say, it crosses a water-parting line, and from its summit streams descend in opposite directions. The descent from the Zoji is very steep on the side of Kashmir, but is gentle on the side of Ladak: the pass itself is grassy and so level for half a mile that the exact water-parting line is difficult to discover. Peaks rise immediately on both flanks of the pass to 14000 feet, and then gradually to 16000 and 17000 feet.

To the casual observer the Punjab Himalaya appear to terminate suddenly at the

Western termination of the Great Himalaya. Indus in the gigantic cone of Nanga Parbat: and even trigonometrical observations have failed to indicate the course of the great range beyond the Indus (see chart xvii).

Schlagintweit considered that on the western side of the Indus the Himalaya and Karakoram (see frontispiece to Part I) could not be separated into chains: "they "form," he wrote, " one mountain mass, the elevation of which decreases very 'rapidly to the westward."‡

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* Ser and Mer, *vide* table vi of Part I. For an exploration of the Nun Kun group see Hunter Workman's address, *Geographical Journal*, Vol. XXXI.

† Sir Richard Strachey's *Himalaya : Encyclopædia Britannica*, Vol. XI.

‡ *Journal, Asiatic Society of Bengal*, Vol. XXVI, 1857.

Colonel Tanner wrote as follows of the country between the Indus and the Kunar (see frontispiece to Part I):—

"The central backbone may be described as a huge broken table-land running up into "wave-like ridges, which rise but a few hundred feet above the general level of the range. "The ridges and peaks on the central backbone are all of nearly the same height, and are "very similar to each other in appearance, and consequently not easy to identify from "points more than a few miles apart. For this reason neither my surveyors nor myself "have been able to fix with accuracy any points on the watershed, nor the passes which "lead over the range, though several have been determined approximately. It is not I "only who have experienced a difficulty here, for the Great Trigonometrical Surveyors, "when prosecuting the Kashmir triangulation, though they have fixed peaks far away "even in the very heart of Kafiristan, have failed to determine more than two or three "points on the entire watershed, a distance of nearly 150 miles. From the beginning of "September the great ocean-like expanse of wavy ridges was snowed up."[*]

At a subsequent date Colonel Tanner referred again to the same region. "We have "now obtained," he wrote,[†] "nearly all the topography of that remarkable region, which "is situated on the northern slope of its ill-defined watershed, and to the eastward a small "portion of the southern slope as well. It is an immense tangle of exceedingly sharp "ridges, which zigzag about in the most perplexing manner. There are hundreds of peaks "of nearly the same height and so like each other that after moving a few miles they cannot "be recognised. One very marked feature in this range is the extraordinary number "of mountain lakes or tarns, which are found as many as three or four together at the "sources of all the small feeders."

Mr. Lydekker has also referred to the uniformity of elevation which prevails in the region north-west of the Indus. "A remarkable feature," he wrote, "along the Indus "valley in Darel, for the notice of which the writer is indebted to Lieutenant-Colonel "Tanner, is that all the peaks over a considerable area reach to a nearly uniform height "of about 21000 feet; thus apparently leading to the conclusion that this level indicates "an old plain of marine denudation, originally bordered by higher ground of which "the peaks of Nanga Parbat and Rakaposhi reaching to over 26000 and 25000 feet "are remnants."[‡]

Trigonometrical surveyors have thus not been able to trace by means of heights the continuation of the Great Himalayan axis beyond the Indus, and the problem will not be solved without a geological survey. It is possible that the range curves in

* *General Report, Survey of India*, 1878-79.

† *General Report, Survey of India*, 1879-80.

The following extract is also from Colonel Tanner's Report for 1879-80: "When I say that I have fixed 145 hill peaks, "I do not wish it to be understood that the points have the accuracy of those hitherto accepted by the Great Trigonometri-"cal Survey. The apexes of some of my triangles are so acute that an error of one minute at either of the ends of the base "would make an error of ten miles in the position of the point. I hope however at some future time to be able to improve "the shape of the triangles, so that my points shall be true to a tenth of a mile."

‡ *Memoirs, Geological Survey of India,* Vol. XXII, 1883.

parallelism to the Karakoram and Kailas ranges, and that the Indus has cut through it at its bend. If the bend is accompanied by a bifurcation, the same difficulty of identifying continuity will occur here as has occurred at the Sutlej.

The country to the west of the Indus has not as yet been geologically surveyed, and we know nothing of the trend of folds between the Indus and the Kunar. We know, however, that in Chitral the prevailing strike of the stratified rocks as observed by Sir Henry McMahon is approximately from north-east to south-west,[*] whilst a similar trend has been observed by Mr. Middlemiss in all the sedimentary series of Hazara,[†] and it is therefore highly probable that a corresponding change of alignment occurs in the ranges of the intervening area.

Though trigonometrical observations failed to determine the trans-Indus extension

Eastern termination of the Great Himalaya. of the great range, they revealed the general surface form of the region, but east of the Brahmaputra no observations have been taken; and nothing is known at all of this extremity of the Himalaya, beyond the meridian of 93°.[‡]

The southerly extension of the Ninchinthangla range shown on chart XVII is purely conjectural.

The Arakan ranges running in directions parallel to one another and perpendicular to the Great Himalaya appear on maps to be compressed unduly close together opposite the extreme point of the latter range; north and south of this point they seem to diverge to a certain extent from one another. If we were to accept the maps as reliable, we might be led to infer that the wrinkles of the Arakan crust had been squeezed together by the resistance offered to them by the point of the perpendicular range: but the country has never been surveyed and the maps cannot be accepted; the apparent crowding of the Arakan ranges against the Himalayan point must have originated in the imagination of a draftsman.

Prince Kropotkin thinks that the Great Himalaya continues as a considerable range through Arakan into China, and that it is cut across by the Salween, the Mekong and the Yangtze. "The great Khingan," he writes, "which is the eastern border range "of the great plateau of east Asia, joins the Himalaya, and consequently in the region "(29° N., 117° E.) where we have on our maps fan-like chains of mountains radiating "between the Salween, the Mekong and the Blue river, there are simply narrow gorges "through which these rivers descend from the plateau."[§]

There are, however, reasons why we are unable to accept Prince Kropotkin's theory: it is improbable that three extraordinary rivers, possessing long Tibetan courses, should develop very close parallel troughs between Tibet and Burma: we believe that

* *Geological Magazine,* Dec. IV, Vol. 9 (1902), p. 5.

† *Memoirs, Geological Survey of India,* Vol. XXVI (1896).

‡ General Walker thought there were no peaks higher than 16700 feet east of longitude 93°. *Proceedings, Royal Geographical Society,* 1887.

§ *Geographical Journal,* Vol. XXIII, 1904.

the troughs in which they flow must be features of original structure : if the three rivers had had to force a passage through the Great Himalaya, they would have probably united before doing so (chart XVII).

It may be found that near longitude 98° the Great Himalaya changes direction to the south-east. On the other hand it is possible that no continuous extension will be discovered, and that the range will be shown to end between the meridians of 96° and 98°.

If we consider the great difficulty of tracing the Himalayan connection across the Sutlej through a tract that is comparatively well-known, we shall realise the futility of theorising upon the unexplored region east of the Brahmaputra. Were a range to maintain similarity of form and uniformity of height on the two sides of a river gorge, no difficulty of identification would arise; but rivers frequently cut across ranges at the very points where the ranges are undergoing change in shape, and destroy the ranges at the places where the differences originate.

Chart XVII illustrates the similarities between the eastern and western terminations of the Great Himalaya. We have as yet no proof that the Ninchinthangla sweeps round on the east as the Karakoram does on the west, but the courses of the rivers in the two regions are very similar. On the north-west we have a number of rivers flowing parallel to the Hindu Kush and crossing the Himalayan alignment at right angles : there are the Indus, the Kishanganga, the Swat, the Kunar, the Panjshir and the Oxus. On the east we observe the same phenomenon : the Brahmaputra, the Salween, the Mekong and the Yangtze all cross the Himalayan alignment at right angles.

On the north-west the several parallel rivers flow into the Kabul river, which flows from the Hindu Kush on a course parallel to the Himalaya : on the east the Zayul river is to the Brahmaputra what the Kabul river is to the Indus. The Raga tributary of the Brahmaputra in Tibet has its counterpart in the Shyok tributary of the Indus (charts XXX and XXXIV of Part III).

We have now to trace the crest-zone of the Great Himalaya and to observe its variations in height. From the ten Himalayan groups of peaks described in Part I and tabulated on pages 37 and 38, we can determine the lengths of the Himalayan axis carrying peaks of 24000 feet and higher, and the lengths of axis on which no such peaks occur.

The variations in the height of the crest of the Great Himalaya.

In chart XIII a longitudinal section along the crest-line of the Great Himalaya range, from the Indus to the Tista, has been drawn to illustrate the principal gaps in the line of great peaks.* In the following table are given, *firstly*, the several lengths

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* We have not sufficient information to justify us extending the section from the Tista to the Brahmaputra.

of crest-line which have been observed to carry peaks exceeding 24000 feet, and, *secondly*, those lengths on which no peaks of 24000 feet have been discovered :—

TABLE XXV.

The elevated portions of the range.	The depressions of the range.	Length of continuous crest-zone carrying peaks exceeding 24000 feet.	Length of depressions in crest-zone where no peaks of 24000 feet occur.
		Miles.	Miles.
Kinchinjunga group of peaks	....	7	....
....	Passage of the Arun Kosi .	....	63
Everest group of peaks . .	....	35	....
....	Passage of the Bhotia Kosi .	....	60
Gosainthan group of peaks .	....	2	....
....	Passage of the Trisuli Gandak	....	39
Group V *	....	1	....
....	Passage of the Buria Gandak .	....	34
Group VI*	....	10	....
....	Depression of range . .	....	26
Group VII * . . .	....	18	....
....	Passage of the Kali Gandak.	....	21
Dhaulagiri group . . .	....	17	....
....	Depression of range .	....	223
Nanda Devi	....	1	....
....	Depression of range .	....	470
Nanga Parbat . . .	....	2	....

Aggregate length of crest carrying great peaks   93

Aggregate length of gaps and depressions   936

Ninety miles of the crest-zone of the Nepal Himalaya carry peaks exceeding 24000 feet : the twin peaks of Nanda Devi are the only points of the Kumaun Himalaya that rise above 24000 feet, and the peaks of Nanga Parbat the only points of the Punjab Himalaya.

If complete maps existed of the Himalaya, the whole area would be found to be dotted with passes : the number of passes runs into thousands, and no attempt has been made in this paper to compile a catalogue.

Passes over the Great Himalaya.

Passes do not as a rule possess any scientific interest ; they are mostly situated on the crests of spurs and minor ridges, and are seldom found upon the axes of the great ranges. We will take the cases of a few well-known passes to illustrate our meaning. The Tipta (15600 feet), for example, is a much-frequented pass

of eastern Nepal, but it has no geographical significance; it is situated on the crest of a southern spur of the Great Himalaya,—a spur that has been carved altogether by water,—and it allows travellers to cross from the valley of the Tambar Kosi to that of the sister-river the Arun. The Rohtang pass (13000 feet, chart XXXII) and the Hamta (14000 feet) cross the eastern section of the Pir Panjal range between Kulu and Lahaul and are on the water-parting between the Beas and Chenab. The Buran ghati* (15121 feet) and the Shatul (15555 feet) cross the eastern section of the Dhauladhar range south of the Baspa. The Kamri (13250 feet) and the Burzil (13500 feet) cross weather-worn ridges north of Kashmir. Even the Manirang (18600 feet), south of the Spiti basin, and the Baralacha (16047 feet), north of Lahaul, cannot be regarded as crossing the Great Himalaya.

In the Nepal and Kumaun Himalaya travellers pass from India into Tibet along the channels of the great rivers : these channels, difficult though they are, furnish readier means of access than mountain paths above the snow, and passes over the range are consequently not necessary. The defile of a river is sometimes regarded as a "pass," but when entered upon a map, the word "pass" almost always denotes the highest point of a path, with an ascent to it from one side and a descent from it on the other.†

The Bhotia Kosi and Dudh Kosi rivers (chart XXVIII) rise in the Great Himalaya range but north of its axis, the former at the Thanglang pass (18460 feet), the latter at the Pangula (20000 feet). These passes are the highest points of routes connecting Nepal and Tibet, but they are not situated on the axis of the great range, being 30 or 40 miles in rear of it. The rivers have cut down the axis and the passes cross only the northern flank of the range. Similarly the passes into Tibet from the Tista basin, the Koru (16900 feet), the Naku (18186 feet), the Donkia (18100 feet), are over the northern flank of the great range but not over the axis ; the Tista has carved a bay out of the range behind the axis and the passes lead over the northern edge of the bay. The Tang pass (15200 feet), however, near Chumalhari, at the head of the Chumbi valley, is a pass over the axis of the great range itself.

The Punjab Himalaya, not having been pierced by rivers, furnishes more examples of passes crossing the axis than the mountains of Nepal and Kumaun. A notch in a range does not become a "pass," until it is frequented by travellers, and though notches in Nepal are probably as plentiful as in the Punjab, they are not used as passes. In the Punjab the absence of river-gorges through the range obliges men to cross the crest-line, if they wish to enter Tibet, and several passes, of which the Zoji (11300 feet) is the best known, do traverse the axis of the great range.

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* The "Boorendo" of Gerard, 1821.

† The English word "pass" denotes any narrow passage. The Afghan word "Kotal" and the Tibetan word "La" denote the highest point of a mountain path, with an ascent to it on one side and a descent from it on the other. The topographical *symbol* for "pass" is only applied on maps to *Kotals* or *La-s*, but the *word* "pass" has been applied also to long river beds like the Khyber and Bolan.

The Siwalik range.

The Siwalik range separates the Himalaya mountains from the plains of India

Its age and continuity.
and is the southern border range of the Tibet mountain system. Though its upheaval was accompanied by movements of the Himalayan mountains themselves, and probably by increases in the latter's elevation, yet the Siwalik range is of more recent formation, and is, perhaps, the most recently formed range of similar magnitude on the earth. It is still in the first stage of growth, and it may be expected in the future to rise in altitude and to expand in width.

With the exception of a short distance of 50 miles, opposite to the basins of the Tista and the Raidak, the Siwalik range has been shown by geologists to skirt the Himalaya throughout their length with remarkable uniformity for 1600 miles, from the Brahmaputra to the Indus and even to the west of the Punjab.

At the passage of the Sutlej there is a break—not a bend—in the alignment and the two lengths of range appear to overlap. Figure 2 of chart XIX shows how the range north of the Sutlej is not a direct prolongation of the one to the south.* If the elevation of the Siwalik range continues now to increase, and at a rate sufficient to dam the Sutlej, the present overlap will be converted into a sinuosity of the crest-line and water-parting, such as is often seen on great ranges, and the present defile of the Sutlej will become a "pass."

In places the Siwalik range is pressed against the outer Himalayan ranges, and

Its "duns."
its existence would be overlooked by the casual observer: in other places, it is separated from the Himalaya for distances of 20 or 50 miles and encloses canoe-shaped longitudinal valleys called "duns."† The best known of these is the Dehra Dun, that stretches from the Ganges to the Jumna : deposits of rounded stones, gravel and sand have been brought down to the Dehra Dun from the Himalaya and have raised its surface 1000 feet above the level of the plains beyond the Siwaliks. Other duns near Kumaun are the Kotah, Patli, Kothri, Chgumbi, and the Kyarda, and many exist in Nepal ; but they are not found north of the Ravi.

The Siwalik range is strongly developed opposite the Dehra Dun with steep south-

A bifurcation.
ern slopes and gentle northern : near the centre of this dun the range bends through an angle of 40 degrees, a similar bend being observable in the outer Himalayan range, 15 miles to the north. On the convex side of its bend, following the example of its great Himalayan neighbour, the Siwalik range threw off a branch range, remains of which are still visible in the hill of Nagsidh (see figure 3 of chart XIX). As is a common occurrence in the great Himalaya, the Siwalik range is crossed by a defile at the very point of its bend.‡ Figure 1 of chart XIX illustrates another bifurcation in the Siwalik range.

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* Atlas sheet No. 47. Scale 1 inch=4 miles.

† Vide *Physical Geology of the Sub-Himalaya of Garhwal and Kumaun*, by C. S. Middlemiss : *Memoirs, Geological Survey of India*, Vol. XXIV. 1890.

‡ The defile is the Mohan pass, see Atlas sheet 48 N. E. : also see sheets of the Dehra Dun and Siwalik Survey.

The Ganges bounds the Dehra Dun on the east, and east of the Ganges the Siwalik range is compressed against the outer Himalaya : it is deserving of note that the Ganges cuts through the two ranges near their point of conjunction.

The Siwalik range is composed of the same material, hardly consolidated, that forms the deposits of the level plains of northern India.

Its rocks.

The Siwalik zone was formerly the northernmost belt of the flat alluvial region : it has been compressed by lateral forces into a long fold or range. The folding of the Siwalik strata shows that the whole Himalaya must have advanced southwards.* The thickness of the strata in the Siwaliks exceeds 15000 feet ; these immense deposits were all brought down by the Himalayan rivers and upheaved in recent times. The rocks of the Siwaliks are entirely of fresh-water origin and prove that the sea has not washed the base of the Himalaya since the eocene period.†

The Siwalik range is of so recent a growth that its features are for the most part the direct results of crustal deformation, and are con-

Its configuration.

sequently very different from those of the outer Himalaya which have been mainly modelled by river erosion.

The Siwalik range is cut across by the great rivers of the Himalaya, but no open mountain valleys have been developed by its own streams : the latter are mere torrents, and are enclosed by precipitous walls. Its ridges and spurs are narrower, more sharply edged and more inaccessible than those of the outer Himalaya.

The Siwalik range is of importance because of its proximity to populated tracts, its wonderful continuity, and its geological interest, but from the point of view of magnitude it cannot be compared with any other range of the frontispiece to Part 1 ; the smallest ranges of the chart are the Lesser Himalaya and the Siwalik, and of these two the former is immensely larger than the latter.‡

The Lesser Himalaya ranges.

The Great Himalaya and the Siwalik ranges are two long parallel folds of the earth's crust,—about 90 miles apart from axis to axis (charts XIV and XV). The region enclosed between them is occupied by the intricate system of ranges we have called the Lesser Himalaya and which we have briefly mentioned on page 75. If we allow for the widths of the Great Himalayan and Siwalik ranges themselves, the zone occupied by the Lesser Himalaya averages perhaps 50 miles in width.

The contortions of the strata show that the Lesser Himalaya region has everywhere been compressed horizontally. These mountains are however the result not

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* *A Manual of the Geology of India.*

† Presidential address by Colonel Godwin-Austen to the Geographical Section of the British Association for the Advancement of Science, 1883.

‡ Objection may be taken to the occasional use that has been made of the plural form *Siwaliks*. We have ourselves no liking for it, but find it difficult to avoid. The plural form is undoubtedly in general use by residents. Similar plural forms are applied to many mountains, such as the *Alps*, *Appenines*, *Pyrenees*. We have however avoided employing the form *Himalayas* in this paper.

of one but of many movements of the crust and their history is more complex than that of the Siwaliks : ranges have been uplifted, and have been afterwards forced to change direction : the whole region has been subjected to successive compressions, and the general wrinkling process is probably still continuing.

In Kashmir and parts of Nepal, where outer ranges are distinct, flat alluvial valleys are enclosed behind the Lesser Himalaya, like the " duns " of the Siwalik and like the plains of Tibet, but in Kumaun, though rivers may run for miles parallel to the mountain axes, the longitudinal and high level alluvial valleys are absent.

Cunningham in his work on Ladak writes : " The inferior mountains of the eastern "chain generally run at right angles to its axis, whereas those of the western chain " are mostly disposed in subordinate parallel ranges." We do not think that this view is correct. Cunningham was probably borrowing his ideas of the Nepal Himalaya from the writings of Brian Hodgson. Though the inferior mountains of Kumaun and of parts of Nepal do not run so clearly parallel to the axis of the great chain, as those of the Punjab, yet throughout the Lesser Himalaya the governing lines are parallel and the most striking characteristic is parallelism.

If we attempt to analyse the Lesser Himalayan ranges, we find that they can be divided into two classes : (a) those that branch from the Great Himalaya, (b) those that are separate folds. The branch ranges of the first class run obliquely across the mountain area ; the separate folds of the second class follow curvilinear alignments parallel to the great range.

The great range bifurcates generally at the points where it is changing its alignment, and each successive branch range adopts the alignment, which the trunk range is forsaking. Having traversed the mountain area obliquely the branches slowly alter their direction and finally run parallel to the great range.

We may classify the seven known ranges of the Lesser Himalaya as follows :—

        the Nag Tibba,
        the Dhauladhar,
        the Pir Panjal,
        the North Kashmir.

These four ranges are oblique and are separate branches of the great range.

The three outer ranges, which may or may not be different sections of one long range, are—

        the Mahabarat,
        the Mussooree,
        the Rattan Pir.

The Nag Tibba range.

The most easterly oblique range, that is known to us, branches from the Great

Himalaya near Dhaulagiri (figure 1, chart XVI) and runs at first in prolongation of the great range's alignment. It continues in a straight line strongly developed across the basin of the Karnali ; it passes through Almora, Nag Tibba and the Chur,* and conjoins with the Dhauladhar range near the Bara Bangahal (chart XVIII). For over 100 miles in Kumaun this range is without a break, and it compels the Alaknanda, the Pindar and the Sarju to flow parallel to it along its northern flank : the Alaknanda and Pindar rivers combine to pierce it north of Hardwar, and the Sarju combines with the Kali to pierce it near the western border of Nepal.

Twenty-four miles west of Dhaulagiri (26795 feet) the highest peak of the Nag Tibba range is 23750 feet: at 52 miles the highest peak is 19875 feet, at 70 miles 15000 feet, at 96 miles 12000 feet ;† south of the Pindar river its peaks are 9000 feet. These figures indicate how the branch declines in height on separating from the trunk range.‡

The Dhauladhar range.

The second oblique range branches from the great range near Badrinath, and runs south of the Baspa tributary of the Sutlej. It is cut in two by the Sutlej at Rampur and by the Beas at Larji ; and it is crossed by the Ravi south-west of Chamba. The northern flank of the Dhauladhar range impinges against the southern flank of the Pir Panjal range at the mountain knot of Bara Bangahal.§ The bifurcation near Badrinath is illustrated in figure 3, chart XVI, and the conjunction of flanks at the source of the Ravi in chart XVIII.

The Pir Panjal range.

The third oblique range leaves the great range at the Sutlej (figure 4, chart XVI), and forms the water-parting between the Chenab on one side and the Beas and the Ravi on the other. It bends towards the Dhauladhar range near the source of the Ravi, and the clash between their flanks has created the mountain knot of Bara Bangahal (chart XVIII). The Pir Panjal is the largest of all the Lesser Himalayan ranges, and even at its extremity in Kashmir it carries many peaks exceeding 15000 feet.‖ South of Lahaul a considerable area rises above the snow line and numerous glaciers exist: south of Kashmir there are no glaciers, but in places snow lies throughout the year.

The North Kashmir range.

The fourth oblique range branches from the great Himalaya near the Zoji pass : it constitutes the water-parting between the Jhelum and Kishanganga, the latter river draining the angle formed by the bifurcation. Its height is greatest near the point of

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* The Chur is a remarkable double peak (11966 feet) twenty-five miles south-east of Simla. It is composed of granite and is supported by seven buttresses. It exceeds in height by 1500 feet all points within thirty miles of it. Though so prominent it is less high than the peaks of the Pir Panjal range. In 1816 Captain Hodgson and Lieutenant Herbert determined the difference of height between the two peaks of the Chur as 460 feet; the higher peak they found to be 1¼ miles north of the lower. Atlas Sheet No. 47.

† Between latitude 29° 10′ and 29° 20′, and longitude 82° and 81° 30.′

‡ It is 17776 feet in longitude 82° 30′, 15000 in 82° 10′, 12000 in 81° 30′, and 9000 in 80° 45.′

§ Map of Kangra, 1 inch = 2 miles ; Atlas Sheet No. 47.

‖ Map of Kashmir, 1 inch = 2 miles.

bifurcation, one of its peaks, Haramukh* (16890 feet), reaching above the snow-line, but westwards it ramifies and declines. For the first 100 miles of its length it is without a gorge: its width exceeds 30 miles.

The Mahabarat range.

West of the Singalila ridge an outer parallel range, known as Mahabarat, traverses the basins of the Kosi and Gandak; it is strongly marked and continues through western Nepal.† Immediately to the east of Singalila, however, no such range is visible, all the lesser ranges having disappeared from the basin of the Tista. Further to the east in Bhutan trigonometrical observations have disclosed the existence of an outer range in latitude 27½°.

The peaks of the Mahabarat range vary from 6000 to 8000 feet, dwindling near the left bank of the Kosi to 5000 feet; throughout its length this range, though serrated like the edge of a saw, offers but few recognisable points to trigonometrical surveyors.

The Mussooree range.

Between the Ganges and Sutlej there is an outer alignment of hills, of which Sirkanda (9080 feet), Landour (7464 feet), Banog (7433 feet), Badraj (7320 feet), and Kasauli (6322 feet) form prominent points: whether this is a remnant of a more southern range, now almost extinct, or whether it originally formed a flank of the Nag Tibba range, 10 miles to the north, we are unable even to conjecture: nor can we tell at present, whether this so-called Mussooree range is a continuation or not of the Mahabarat range of Nepal.

The line of mountains we have called the Mussooree range has barred the exit of the Ganges from the mountains and has forced the Bhagirathi, the Alaknanda, and the Navar affluents to unite in rear of it: the junction of the Tons and the Jumna is also due to its presence.

The Rattan Pir.

South of Kashmir the outermost range is known as the Rattan Pir. This range may be the western extremity of a long outer range, pressed near Kashmir against the Pir Panjal range, or it may be an old flank of the Pir Panjal range itself and not a separate fold. It is separated from the Pir Panjal by the river Punch.

If the Lesser Himalaya had consisted of the oblique ranges only, the mountains might have terminated in the plains of India as diverging and diminishing chains — increasing in number and decreasing in magnitude—like the Hindu Kush in Afghanistan and the Kuen Lun in China. But one or more outer ranges seem to have been upheaved parallel to the great range and these appear to have pressed back the oblique ranges and to have formed a curvilinear wall stretching almost unbroken for 1600 miles from the Brahmaputra to the Indus. If the sea were now to flow over the Indo-Gangetic plains, the Himalayan coast would be a long wall without capes or islands.

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* The trigonometrical station of Haramukh is 16001 feet high and one mile north-west of the peak.

† We can trace it from longitude 86°, latitude 27½°, through 85°, 27¾° and 83°, 28° to 80½°, 29¼°.

If we examine chart xxiii of Part III, or the drainage charts xxiv to xxxiv, we find that the river basins of the Nepal Himalaya are disposed symmetrically with regard to the ranges, but that this is not the case in the Punjab Himalaya. The Himalayan basins of the Tista, the Kosi, the Gandak and the Karnali are of simple and symmetrical shapes, such as would be expected to result from rivers flowing down from a great range. But the basins of the Sutlej, the Beas, the Ravi, the Chenab and the Jhelum are disposed obliquely with regard to the Himalayan alignments: the axes of these basins are parallel to one another but inclined at an angle to the line of snow peaks.

The symmetry of the Nepalese basins is due to the fact that the Lesser Himalaya ranges in Nepal are mainly parallel to the great range: the obliquity of the Punjab basins is due to the Lesser Himalayan ranges in the Punjab being mainly oblique.

15

THE RANGES OF SOUTHERN TIBET.

The three principal ranges of Southern Tibet are the Zaskar, the Ladak, and the Kailas.

The Zaskar range.

The Zaskar range appears to bifurcate from the great Himalayan range near Nampa (see figure 2, chart xvi), but the exact position of the bifurcation is not known.

The Zaskar range, after leaving the Great Himalaya, culminates in the peak of Kamet (25447 feet) : near the point of its intersection by the Sutlej the twin peaks of Leo Pargial (22210 feet) rise from it, and in the basin of the Spiti river it carries the peak of Shilla (23050 feet). Beyond the Indus-Spiti water-parting its peaks rise to 20000 feet, but further to the north-west they do not exceed 18000 feet.

Through the basin of the Indus the Zaskar range can be traced at intervals run-
Its continuity. ning in a north-westerly direction parallel to the Great Himalaya :* the region it traverses north-west of Spiti is, however, occupied by complex ramifications of mountains, apparently branching in many directions, and there does not seem to be any definite continuous axis to which all the ridges belong. In some places the Zaskar fold can be clearly seen : in others there appear to be two or more close parallel folds. The continuity of the range as drawn in the frontispiece to Part I has not, we think, been demonstrated.†

Sir Alexander Cunningham refers to the Zaskar range in his work on Ladak, and is confident from personal observation of its continuity : " It extends," he writes, " in " one unbroken chain through the districts of Chumurti, Rukchu, and Zaskar to the " junction of the Zaskar river, which rushes dark and turbulent through a vast chasm in " the mountains where human foot has never trod. From this it extends to the junction "of the Dras river with the Indus, where it is again cut through by the Dras river at a " narrow gorge called the Wolf's Leap ; but beyond this point it stretches in one unbroken " chain to the great southward sweep of the Indus."

The parallelism of the upper feeders of the Kali, in the beds they have carved out
Corrugations. for themselves along the eastern portion of the Zaskar range, suggests the possibility of the surface of the range having been originally corrugated. ‡ The Dharma, the Lissar and the Kali itself rise in the Zaskar range and flow in long parallel troughs of the crest-zone at five-mile intervals : their courses are inclined to the direction of the range as though they are the troughs of minor folds obliquely superposed upon the main Zaskar fold.

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* Sheets 5 and 6, Punjab map, 1 inch=8 miles.

† Colonel Godwin-Austen drew three parallel ranges where we have drawn the single Zaskar. (See *Report, British Association for the Advancement of Science*, 1884.) He had an intimate knowledge of the geology of the region.

‡ Atlas sheet 66 N. E.

A great transverse spur protrudes from the Zaskar range at Kamet into the upper

Transverse ridges.

basin of the Alaknanda. For a length of 20 miles its peaks exceed 20000 feet; its altitude then diminishes to 14000 feet in 6 miles, and it is not visible south of the Dhauli at Joshimath.* It is this extraordinary buttress of Kamet that separates the basins of the Vishnuganga and Dhauli behind the great Himalayan range (chart XXIV, Part III). Its magnitude and continuity suggest the idea that it is a structural fold due to cross pressure.

The western boundary of the Spiti basin seems also to be a transverse range branching at right angles from both sides of the Zaskar range.

The Zaskar range, being the water-parting between the Kumaun Himalaya and

Passes over the Zaskar range.

Tibet, is crossed by a great number of well-known passes : the Lipu Lekh (16750 feet) is south of the Upper Karnali basin, and near the conjunction of the Zaskar and Great Himalayan ranges. The Manghang, Lankpya and Dharma passes are about 18000 feet, the Untadhura is slightly below 17500 : these passes lead to Tibet out of the basin of the Kali. The Kingri Bingri (18300 feet), the Balchha (17500 feet), the Shalshal (16200 feet), the Silikank (18000 feet) and the Niti (16500 feet) are all passes across the water-parting between the Dhauli affluent of the Alaknanda and Tibet, and they by no means constitute a complete list. The Mana pass (18000 feet), called also the Dhungri or Chirbitya, is at the head of the Saraswati affluent of the Alaknanda.† The Muling pass (height unknown) crosses the water-parting between the Bhagirathi and Tibet. The Gumrang and Sholarung passes are further west and connect the Himalayan basin of the Sutlej with its basin in Tibet.

The Ladak range.

The western portion of this range was called by Sir Alexander Cunningham the Kailas range, on the supposition that the peaks of Kailas rose from its easterly continuation. But the Kailas peaks stand north of the Manasarowar lakes, and the continuation of Cunningham's Kailas range has been found to pass south of Manasarowar (figure 1 of chart XXI, and frontispiece to Part I). Many writers have followed Cunningham, but Drew adopted the name " Leh " range. Godwin-Austen called it the "Ladak" range, because it was the principal feature of Ladak. We have accepted the name Ladak, and have applied it to the whole range from Assam to Baltistan. We are not, however, in a position to certify that a continuous range stretches in rear of the Great Himalayan range throughout the whole length of the latter from east to west.

In rear of the Assam Himalaya the Ladak range is strongly developed, and forms

The southern water-parting of the Brahmaputra of Tibet.

the water-parting between the Brahmaputra of Tibet and the Brahmaputra of Assam.

North of the Chumalhari peak of the Great Himalaya, the Nyang river has cut through the Ladak range, and drains northwards into the Brahmaputra.‡ Westwards

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* Kumaun and Garhwal Survey, 1 inch=1 mile. Atlas Sheet, No. 65, 1 inch=4 miles.

† The Saraswati is a feeder of the Vishnuganga. The names of passes are spelt in various ways, and much uncertainty prevails.

‡ North-eastern Frontier Sheets, 6 N. W. and 6 S. W., 1 inch = 4 miles.

from the Nyang basin, as far as Lake Manasarowar, the Ladak range is the water-parting of the Brahmaputra, and the drainage of its southern slopes passes across the Great Himalaya into India. The bend in the water-parting at Chumalhari, as drawn on charts XXIII and XXXV, is therefore due to the Nyang river : at this one point the Great Himalaya becomes the water-parting, and the trough to the north of it drains into the Brahmaputra of Tibet.

Westwards from the Nyang basin for a distance of 200 miles, the Ladak range and the Great Himalaya run parallel and enclose between them the long trough of the Arun river, the plains of Dingri, and of Digur Thanka and the lake of Palgu.*

In rear of the bifurcation of the Great Himalayan range at Dhaulagiri the Ladak range increases in elevation, and the trough separating it from the Great Himalaya becomes less distinct.

Behind the Karnali basin the range is strongly developed ; it culminates south of Manasarowar in Gurla Mandhata. Immediately west of this great peak the continuation of the range is not distinct.† The gap here is more difficult to explain than the gorge cut by the Nyang, and it is this break in continuity that mainly prevents us from stating definitely that the Ladak fold is continuous. To give a single name to one long range is advantageous, in that the name indicates the position maintained by the range with regard to other ranges. But identity of name implies identity of origin, and whether one long fold extends through Gurla Mandhata from the east of Tibet to the west, is a question that has not been finally decided. The apparent break near Gurla may have been a feature of original structure ; the range east of Gurla may be overlapping that from the west ; or a portion west of Gurla may have subsided, or have been deflected by recent pressures ; or the Ladak range and the range to the north may have expanded sympathetically at Manasarowar, and their flanks have been merged by pressure (figure 1, chart XXI).‡ From information at present available it appears more correct to give one name to the whole range and thereby to imply continuity, than to give different names to different lengths and thereby to imply independence.

When we consider what small accidents of heterogeneity or of resistance in the crust are sufficient to break the uniformity and continuity of a long fold, our wonder is that the ranges of southern Tibet, subjected as they have been to ever varying cross pressures, are as continuous and as uniform as they are.

East of Manasarowar the Ladak range runs south of the Brahmaputra, and, except at Chumalhari, forms the water-parting : west of Manasarowar the range follows the Indus, and its relations to this river are extraordinary.§ The frontispiece to

Side note: Continuity of the range.

Side note: Intersections of the Ladak range by the Indus.

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* Map of Nepal, 1 inch=16 miles.

† Northern Frontier Sheet, 14 S.-W., 1 inch = 4 miles. Ryder's map of southern Tibet, *Geographical Journal*, Vol. XXVI.

‡ On chart XXI this contact between the ranges is called a conjunction : it is however a clash of flanks only and not a conjunction of axes : the thick lines on the chart show only the axes of the ranges and give no idea of their spans.

§ Sheets 5 and 6, Punjab map, 1 inch=8 miles.

Part I shows how the Indus and the Ladak range are intertwined : for the first 180 miles from its source the Indus flows along the trough north of the Ladak range and parallel to the range : near Thangra, north of Hanle, it bends at right angles, cuts across the range, and forsakes the trough it has been occupying. It now flows for 300 miles along the south flank of the Ladak range, and then, shortly before its junction with the Shyok, passes back across the range to its original side. It remains on the north side for 100 miles and then cuts across the range for the third time.*

At the intersection near Hanle the range is strongly developed, and that it is cut through there can be little doubt. On both sides of the river-gorge the core of the range is found to be of granite, and the alignment is found to be the same.

The troughs on either side of the Ladak range in Ladak are comparatively open and contain but small impediments to the flow of the mighty river : the behaviour of the latter in cutting constant gorges through a granite range in preference to pursuing a straight and simple course is most eccentric. As a geographical feature it is unique.† We can only suppose that the Ladak range has grown, since the Indus began to flow, and that like a tree trunk embraced by a creeper, it has in its expansions had grooves cut across it by the river.

But little is known of the Ladak range between the Sutlej and its intersection by the Indus near Hanle ; nothing is known of it east of longitude 91°, or west of longitude 74°.

A great number of passes cross the Ladak range : on its north-western section
Passes over the Ladak range. south of the Indus are situated the Harpo (16785 feet), the Burgi (15697 feet), the Bunnuk. Behind Leh are the Lasirmou (16900 feet), and the Laowchi or Khardung (17600 feet).

Between Leh and the intersection of the Ladak range near Thangra by the Indus the principal pass is the Kay (18250 feet). Between Hanle and Manasarowar are the Medosi (17700 feet), the Boga (19200 feet) and the Ayi (18700 feet) : south of the lake Rakas Tal are two passes over the Ladak range, height 17100 and 18200 feet : north of Nepal there are the Photu (15080 feet), the No (16600 feet), the Taku, the Sheru (17600 feet), the Kura (17900 feet) and others.‡

The Marsemik, Dumche, and Chang passes are on the Kailas and not on the Ladak range.

The Kailas range.

The Kailas range runs parallel to the Ladak range fifty miles in rear of it (figure 1, chart XXI). Near Manasarowar it contains a crowded cluster of peaks, several of which exceed 20000 feet, and the highest of which is Kailas (22028 feet). Opposite to

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* In the frontispiece of Part I the third intersection of the range by the river is drawn at Bunji near the great knee-bend of the Indus : the continuity of the range has, however, not been proved. It is clear that the Indus must pass somewhere in this region across the range to the south, but it is not certain where it does so. The return passage may occur a little west of longitude 76° : if that be the case, the range should have been drawn on the chart nearer to the Kailas range, and the Zaskar range should have been produced across the Indus at the point on the chart where the Ladak range crosses it.

† Compare, however, the intersections of the Zaskar range by the Spiti river. On chart XXXI of Part III the course of the Zaskar range can be traced from its peaks of Shilla, Leo Pargial, and Kamet.

‡ The names of passes are spelt in different ways, and it is not possible to say which are the correct forms. The Khardung pass is described in the *Marches of Hindustan* by David Fraser. Ryder crossed the Kura Pass in 1904, *vide* *Geographical Journal*, Vol. XXVI, p. 383.

the culmination of the range in the Kailas peak, the Ladak range culminates in Gurla Mandhata; both ranges expand at this point and their flanks come into conjunction.

East of Manasarowar the Kailas range forms generally the northern rim of the Brahmaputra's trough: it cannot, however, be called the water-parting, as it is cut through in places by rivers from the north.

East of longitude 85° the Kailas range bifurcates* (frontispiece to Part I), and

A branch from the Kailas range. for nearly 150 miles the river Raga (chart xxx) flows along the trough between the two branches.

Immediately after bifurcation the branch range is crowned by a cluster of peaks, many of which were found by Captain Wood to exceed 20000 feet; peaks of 18000 feet have been found upon it as far east as its intersection, in longitude 87° 45′, by the main stream of the Brahmaputra: its height diminishes near its intersection by the Nyang but increases again to 18000 feet further east.

The branch range appears to conjoin with the Ladak range near Lake Yamdrok: this section of it was called by Ryder the Karo La range.†

After throwing off its branch the main Kailas range runs eastwards with peaks

Continuity of the Kailas range. of 20000 feet. Trigonometrical observations show that it joins with a range of Tibet, known as the Ninchin-thangla, in longitude 88°. After this conjunction the Kailas range itself continues to trend in its former alignment as far as longitude 92° and possibly further. Nothing is known of the Kailas range east of 92°.

Near Manasarowar the Kailas range is strongly developed and the ranges to the south of it expand here in sympathy. Within one region are to be found the culminating peaks of four different ranges,—Kailas, Gurla Mandhata, Kamet and Nanda Devi.

From Manasarowar the Kailas range can be traced along the north bank of the Indus as far as the Pangong lakes. In longitude 80° it is intersected by the Singhgi, the eastern branch of the Indus.

On reaching the Pangong lakes it appears to end in the peak of Sajum (20018 feet),

A break in the continuity. but further west it can be traced again, and then forms the water-parting between the Shyok on the south and the Nubra on the north: the alignment from Sajum to the junction of the Nubra and Shyok has not been determined, and the range has been broken on the frontispiece to Part I to denote uncertainty.‡ It is possible that the Kailas range has clashed with the Ladak west of Sajum peak, and that for a short length the two ranges are

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* The Ladak range appears to bend sympathetically opposite to the bifurcation. Sheets 22 N. W. and 22 N. E., Northern Frontier, 1 inch = 4 miles. This part of Tibet was surveyed by Ryder in 1904, vide Report on survey operations on the journey from Gyangtse to Simla viá Gartok.

† North-Eastern Frontier Sheet 6 N. E., 1 inch = 4 miles.

‡ North of Leh the Kailas range is clearly marked. Sheet No. 5, Punjab map, 1 inch=8 miles. For Sajum peak see map of Turkistan, 1 inch=32 miles.

here welded together. It is also possible that vertical subsidences have destroyed the continuity of the Kailas near Pangong.

West of the junction of the Nubra and Shyok the Kailas range runs parallel to its northern neighbour the Karakoram ; the long troughs occupied by the Biafo, Hispar and Chogo Lungma glaciers lie between the Kailas and Karakoram ranges.

Opposite the kneebend of the Indus near Bunji the Kailas range is crowned by

Culmination and termination. the peak of Haramosh (24270 feet).* Within nine miles of its intersection by the Hunza river stands Rakaposhi, its highest peak, and it is near this point—the point of intersection and of supreme altitude—that the range begins to change its direction. After a long course from south-east to north-west it bends through a wide curve, and then runs from north-east to south-west, declining in height as it bends. West of Rakaposhi, however, its alignment is very difficult to trace ; in this region the range has been so cut to pieces by feeders of the Gilgit and Kunar rivers, that its present appearance resembles a line of detached pyramids (chart xxxiv).

In figure 2, chart xxi, the Kailas range has been extended across the Kunar river at Chitral : but this prolongation is only suggested, and has not been entered upon the frontispiece of Part I.

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* Atlas Sheet 27 S. E., 1 inch = 4 miles. Northern Transfrontier Sheet 3 N. E., 1 inch = 4 miles. Map to illustrate Captain Younghusband's explorations, 1 inch = 16 miles.

16

THE KARAKORAM AND THE HINDU KUSH.

The Karakoram.

The nomenclature of the mountain ranges of Asia has been the source of many difficulties. The applications of names by natives are vague and indefinite; and a mountain chain may even be designated differently in neighbouring villages. In the study of geography the employment of names is a means to an end, and we should therefore endeavour to introduce as simple a nomenclature as possible. It is not necessary to retain several names for a single range; nor is it advisable to abandon a name, after it has been for many years in common use upon maps, because faults come to be found with it.

Moorcroft was the first western geographer to apply the name Karakoram to the great range of mountains, which separates the Indus and Tarim basins. Moorcroft was a careful observer, and he learnt the name from natives in Tibet. For 60 years the name Karakoram was employed by geographers, and throughout the surveys of Kashmir and Baltistan no objections to it were raised by surveyors.

Some 20 or 30 years ago the alternative name, Muztagh, was introduced and an endeavour was made to displace the name Karakoram. There was nothing to be gained by the change, and it has only resulted in confusion. By some writers and map-makers the name Karakoram has been retained, by others the name Muztagh has been accepted, and by others the two names are now given together.

The objection raised to the old name "Karakoram" was that it meant "black "gravel," whereas "Muztagh" means "ice mountain." The original meaning of a name has nothing to do with its suitability: black gravel is found on the slopes of the Karakoram, and Moorcroft relying on native information named the range "black " gravel."

The confusion caused by the introduction of the name Muztagh should be a warning to geographers to accept accomplished facts. Now that the name Muztagh has come to be applied on modern maps to the Karakoram range, explorers are discovering that it is attached to every snow mountain in Chinese Turkistan. The peak Muztagh Ata is not on the Karakoram but on the Kashgar range: Sven Hedin writes of the Kashgar range as the Muztagh range :[*] on the authority of a village headman Dr. Stein gives the name Muztagh to a peak of the Kuen Lun ;[†] Semenoff called the western portion of the Tian Shan "the Muztagh."

Muztagh, meaning "ice mountain," is in fact a description, not a name. Colonel Wahab writes," Muztaghs are as common all over Central Asia as Safed Kohs on our " north-western frontier. The name Karakoram is quite established now for the moun- "tain range separating the Indus and Zarafshan, and is the most suitable."

We are of opinion that the name Muztagh should be used for the peak Muztagh Ata, but not as an alternative for the name Karakoram; the latter alone should in future be applied to the mountain range, of which K^2 is the highest summit.

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[*] Sven Hedin : *Through Asia*, page 670.
[†] M. A. Stein : *Sand-buried ruins of Khotan.*

The earth-fold. The Karakoram and Hindu Kush ranges of mountains are different sections of the same crustal fold. The fold traverses western Tibet from south-east to north-west, curves round through Hunza and Gilgit, passes north of Chitral, and enters Afghanistan in a direction from north-east to south-west.* The eastern portion of the fold is known as the Karakoram range, the western portion as the Hindu Kush.

The range does not change its name at any particular natural feature; but, as the limits of application of the two names require to be settled for the convenience of geographers, it will perhaps be well, if we call the mountain chain in Tibet and Hunza the "Karakoram," and in Gilgit, Chitral and Afghanistan the "Hindu Kush." The water-parting between the Hunza and Gilgit rivers (charts xx and xxxiv) situated some ten miles east of the meridian of 74° will then form the dividing line.†

Gaps in the Karakoram range. In chart xx a longitudinal section of the Karakoram has been drawn to explain graphically the causes of the gaps in the range. This section has been made to follow the curved alignment of the Karakoram and Hindu Kush ranges. A comparison of the section against the groups of peaks, described in Part I, will show how the range is divided into blocks: the following table gives both the continuous lengths of range that carry peaks higher than 24000 feet, and the intervening gaps, where no such peaks exist : —

TABLE XXVI.

The elevated portions of the range, carrying peaks of 24000 feet and higher.	The depressions of the range.	Length of continuous crest-zone carrying peaks exceeding 24000 feet.	Length of depressions in crest-zone, where no peaks of 24000 feet occur.
No peaks of 24000 feet have been discovered on the Karakoram east of the Shyok river.			
		Miles.	Miles.
Shyok Nubra group of peaks .	. . . . . .	5	. . . .
. . . .	Passage of the Nubra river .	. . . .	12
Group XII‡	. . . . . .	1	. . . .
. . . .	Crest-zone carries no great peaks.	. . . .	35
Group XIII‡. . . .	. . . . . .	13	. . . .
. . . .	Crest-zone carries no great peaks.	. . . .	22
Karakoram group . . .	. . . . . .	18	. . . .
. . . .	Crest-zone carries no great peaks.	. . . .	60
Kunjut group . . .	. . . . . .	25	. . . .
. . . .	Passage of the Hunza river .	. . . .	22
Hunza-Kunji group . .	. . . . . .	16	. . . .
. . . .	Long depression of range containing the gorges of the Gilgit and Kunar rivers .	. . . .	140
Tirich Mir group . .	. . . . . .	26	. . . .
There are no peaks of 24000 feet west of the Tirich Mir group.			
Aggregate length of crest carrying great peaks		104	. . . .
Aggregate length of gaps and depressions		. . . .	291

* The curvature of its course is sharper than that of the great Himalaya.
† Northern Transfrontier, Sheet No. 2 : 1 inch=8 miles. As a dividing line across a range, a river would be more dis tinct than a water-parting. But water-partings form the divisions between tribes and dialects more often than rivers, and are therefore perhaps the more suitable divisions in nomenclature.
‡ *Vide* page 40 of Part I.

The Shyok, Hunza, Gilgit and Kunar rivers drain the trough *behind* the Karakoram range; the Nubra river rises *in* the Karakoram, the glacier at its source having cut a notch in the crest-zone.

Though the number of great peaks is less on the Karakoram than on the Great Himalaya, there is a greater length of high range, on which great peaks stand without deep intervening depressions. A length of 104 miles of the Karakoram crest carries great peaks against one of 93 miles of the Great Himalaya. The Karakoram rises as it leaves Tibet, culminates in K^2, and then slowly declines : its crest does not show the surgings of the Great Himalaya.

Eastern extension of the Karakoram. The western termination of the Karakoram is the Hindu Kush, but of its eastern termination we know nothing.[*] The peak of Aling Kangri, which stands in Tibet near the eastern source of the Indus, has been supposed to mark the continuation of the Karakoram fold, but chart xx illustrates our inability to draw the eastern section of the range. At Pangong and Rudok, between the known eastern extremity of the Karakoram and its supposed continuation at Aling Kangri, no range appears to exist,[†] but our geographical knowledge of this region is very imperfect.

As we said of the Kailas range when referring to this same region, a portion of the Karakoram may have subsided vertically : on the other hand, the normal height of the Karakoram at this spot may now be above 17000 or 18000 feet, in which case it would be now projecting only 1000 or 2000 feet above the surface of the high level alluvial plains of Tibet and be attracting no particular attention from explorers.

East of Aling Kangri a great range was observed by the explorer Nain Singh. He left Leh in July 1874, and travelled due east from Rudok for a distance of more than 800 miles; an almost continuous range of snow mountains, he said, trended eastwards from Aling Kangri (longitude $81°$) to the Ninchinthangla peaks (longitude $90° 30'$) (see frontispiece to Part I).[‡]

The possible existence of a second Karakoram range. Another question that cannot yet be answered is —Are there two Karakoram ranges parallel to one another ? There are, we shall show hereafter. two Hindu Kush ranges (frontispiece to Part I), and we have not been able to discover where the northern Hindu Kush range terminates towards the east.

North-west and south-east of the peak K^2 we see in rear of the Karakoram range, and at a constant distance from it, a very marked water-parting shown on maps, which curves back from the Karakoram axis in two places (see areas C and H of chart xxxv). It is crossed by numerous passes, the Shimshal (14719 feet), the Khunjerab (15420 feet), the Mintaka (15430 feet), the Kilik (15600 feet), the Karakoram (18550 feet).[§]

What is this water-parting ? Is it a fold of the Earth's crust ? Is it an easterly continuation of the northern Hindu Kush fold, and has it been welded by pressure

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[*] Map of Hundes or Nari Khorsam, 1 inch = 8 miles.
[†] Access to Tibet from the west is easy at this point, *vide* Sir Thomas Holdich's *India*.
[‡] *General Report, G. T. Survey of India*, 1874-75.
[§] The two Muztagh passes, the western of which was crossed by Younghusband, are on the great Karakoram range. Height of western Muztagh pass 19020 feet. Ferber's aneroid value, *Geographical Journal*, Vol. XXX, Dec. 1907, p. 639.

into the Karakoram at K²? These are questions we are quite unable to answer. No second Karakoram range has been shown upon the frontispiece to Part I; its existence as a separate crustal fold is conjectural, and it would be unsafe to draw conclusions as to structure from observations of drainage. It is possible that the Karakoram range has thrown off bifurcations, and that these have complicated the orography.

Even the great Karakoram peaks themselves seem to follow two alignments. The Masherbrum peaks and peak 63 (table v of Part I) surmount a ridge parallel to that on which the peaks of K² and Gasherbrum stand, and at a distance of ten miles from it. Of the Karakoram peaks north-east of K² we have no knowledge, and there is no more likely spot than this for great undiscovered peaks to be existing.

Colonel Montgomerie gave the following account of the mountains of western
Tibet, of which the Karakoram is the backbone: "From

Comparisons with the Alps.

"any point in the Punjab at the foot of the Himalaya
" it takes a man assisted by a pony sixty-six days to cross the mountains; and I think
" that even if a man tried his utmost he could not well do it under fifty-five days; during
" that distance the road is for twenty-five marches never under an elevation of 15000
" feet, and during forty-five marches never descends below 9000 feet."

"The Alps, I suppose, would take, at the outside, three days for a man to cross,
" and I believe that a good walker can cross from a village on one side to a village on
" the other in one summer's day. The Munshi took twenty-five days to march from
" the last village south of the Karakoram to the first village north of the Karakoram."

"In no parts of the Alps," writes Sir Martin Conway, "is there anything like the
" amount of rock ruin, even in proportion to the size of the mountains, that one finds
" in these dry districts of the Karakoram."*

The Karakoram is a more arid and less wooded region than the Himalaya; its topographical features are consequently different. Rain-water runs off more rapidly, less sinks below the surface, and the rocks are not protected to the same extent against variations of temperature by a mantle of verdure.

The Hindu Kush.

Humboldt believed that the Hindu Kush range was a continuation of the Kuen Lun,† and an examination of the frontispiece to Part I shows how natural such a supposition was. Even now we cannot draw the crustal folds of the Pamir plateau or of the region to its south-east.

Trigonometrical observations and topographical surveys have shown that the Hindu Kush consists of two distinct parallel ranges.‡ The highest peaks and the deepest gorges are found on the southern range, and smaller variations of relief on the northern.

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* W. M. Conway: *Climbing in the Himalayas,* 1894.
† A. Von Humboldt: *Cosmos,* Vol. II, page 154.
‡ Holdich's *India,* page 84.

The northern Hindu Kush range bears the same relation to the southern, as the

Drainage of the Hindu Kush trough.

Ladak range does to the Great Himalaya in Nepal : that is to say, the northern is the primary water-parting, and its drainage escapes through the gorges of the loftier southern range.

The Hunza river rises beyond the southern range and cuts through it. Similarly the Gilgit river drains the trough between the two Hindu Kush ranges for 40 miles and escapes through the southern range ; the crests of the two ranges are 13 miles apart in the basin of the Gilgit. The Kunar river drains the interior of the trough for over 50 miles and pierces the southern Hindu Kush range at the Ishpirin defile.* The Panjshir river drains a great length of the trough and passes through the southern range to the Indus.†

West of the peaks of Tirich Mir a portion of the trough appears to belong to the system of the Oxus, and still further west is a second and similar alternation of the drainage.‡ (Chart xx : figure 2 of chart xxi : chart xxxv.)

The frontispiece of Part I and the section in chart xx show that the southern Hindu

Continuity of the Hindu Kush.

Kush range is a western extension of the Karakoram fold,‡ and on page 98 we decided to assume the water-parting between the Hunza and Gilgit rivers as the boundary mark between the two names.

For a distance of 140 miles, from the Hunza-Gilgit water-parting to the peaks of Tirich Mir, the Hindu Kush rises to no great altitude, and the original alignment can in places be only traced by the presence of huge pyramidal masses 20000 feet high, which have been carved out of the range.

North from Tirich Mir a perpendicular buttress projects from the Hindu Kush

The Tirich Mir buttress.

and deflects the Oxus to the north : it resembles the buttress of Kamet (page 92), and in the same way as the latter issues from the culminating point of the Zaskar range, so does the former protrude from the Hindu Kush at the place of its greatest vertical expansion. The association of a giant peak surpassing all its neighbours with a perpendicular ridge seems to indicate that the crust of the region has been subjected to extraordinary cross-pressures.

It will be seen that the drawing in figure 2 of chart xxi does not reproduce the

The clash of ranges at Tirich Mir.

representations of the frontispiece to Part I ; the divergence helps to illustrate the uncertainties surrounding the orographical problem. In the frontispiece of Part I we have shown the two parallel Hindu Kush ranges extending westwards from longitude 74° and forming the basins of the Panjshir and of the Hari Rud : the range pierced by the Kunar river at Chitral is, in this chart, the southern Hindu Kush. In figure 2 of chart xxi we have suggested an alternative solution, and have made

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* Northern Transfrontier Sheet No. 2, 1 inch = 8 miles.

† North-west Transfrontier Sheets Nos. 26, 27, 1 inch = 8 miles.

‡ Chart xx illustrates the southern range only. On this chart the Kunar river has been wrongly called the Yarkhun, which is a local name for one section of the river.

the two Hindu Kush ranges conjoin near the mass of Tirich Mir, and continue there-after as one range.   According to chart XXI the range pierced by the Kunar river near Chitral and the range forming the southern limit of the long trough drained by the Panjshir river are extensions of the great Kailas fold, a further extension of which then becomes the southern rim of the basin of the Hari Rud.*

Westwards from Tirich Mir the Hindu Kush continually throws off minor branches and declines in height : in longitude $68\frac{1}{2}°$ its peaks rise above 16000 feet, in 66° they rise to 12000, in 63° they hardly reach 10000.

It is not known whether the water-parting between the Indus and the Helmand (longitude $68\frac{1}{2}°$) is a structural bifurcation from the Hindu Kush or whether it is a ridge carved by rain : its elevation rapidly diminishes as it extends southwards from the Hindu Kush.

The beds of the great rivers that pierce the southern Hindu Kush range, pro-vide thoroughfares, and the number of well-known

Passes over the Hindu Kush. passes over this range is consequently not large. The Darkot (15000 feet) is perhaps the most important ; it crosses the range opposite to the Baroghil (12460 feet) and Shawitakh (12560 feet) passes of the northern Hindu Kush.

The northern Hindu Kush is pierced by a few torrential streams, but by no great river. It is crossed by an extraordinary number of passes : west of longitude 67° there are the Sharak Kushta, the Barkak and several others between 10000 and 11000 feet. Further east there are the Irak (13500 feet), the Chahardar (13900 feet), crossed by the Afghan Boundary Commission in 1886, the Kaoshan (14340 feet), crossed by Alex-ander the Great, and the Khawak (11640 feet), a great trade route.†   In the Tirich Mir region there are the Dorah (14800 feet), the Agram (16630 feet), the Nuksan (16050 feet), the Khatinza (17500 feet) and the Sad Ishtragh (17450 feet).   Between the last named and the Kilik pass, near the trijunction of the basins of the Indus, Oxus and Tarim, there are numerous passes which average in height about 16000 feet, two of them however being low, namely, the Baroghil (12460 feet) and the Shawitakh (12560 feet). These lists do not pretend to be complete ; a few names only have been mentioned to indicate the general elevation of the lowest notches in the Hindu Kush.

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* Map of Afghanistan, 1 inch = 16 miles.

† Holdich's *India*, page 85.

17

THE RANGES OF NORTHERN TIBET AND TURKISTAN.

The Aghil, the Kuen Lun and the Altyn Tagh.

But little is known of the Aghil range; it was discovered by Sir Francis Young-

The Aghil range. husband, and a few of its peaks have been observed by surveyors; but its length and direction have not been determined. The position given to it on the frontispiece to Part I and its junction with the Sarikol range are conjectural. The peaks observed between the Kuen Lun and Karakoram ranges along the upper courses of the Yarkand river appear to be scattered rather than aligned, and the region seems to resemble in complexity that between the Indus and Kunar rivers.

It may be that the Kuen Lun, Aghil and Karakoram folds have been pressed against one another; all the ranges of Tibet tend to converge at the north-western corner of the plateau, as though they were trying to escape through the neck of a bottle; once having passed the neck they separate again, but during the passage they appear to suffer from extreme compression.

The Kuen Lun range runs in an east and west direction through northern Tibet (*vide*

The Kuen Lun. frontispiece to Part I); as far as we know, there are in the Kuen Lun no outer and lower parallel ranges as there are in the Himalaya, and from longitude 76° to 83° the Kuen Lun may be described as the northern border range of the Tibet mass. It is, however, only west of longitude 83° that the Kuen Lun faces the Tarim desert: east of this its branch, the Altyn Tagh, becomes the border range.*

The absence of outer and lower ranges has an effect upon the drainage: there are in the Kuen Lun no long valleys like the Dehra Dun, and rivers instead of converging, like those of the Himalaya, inside the mountains flow more directly down from the snows, and enter upon the plains in greater numbers and with smaller volumes. South of Khotan and Kiria the rivers issue from the Kuen Lun at intervals of 20 miles; on the Himalayan side the average interval exceeds 50 miles.

From the snows to the plains of India the Himalaya are 80 or 90 miles broad; from their crest to the plains of Tarim the Kuen Lun are 40 or 50 miles broad.

The portions of the Kuen Lun drained by the Yarkand and Karakash rivers are known as the western Kuen Lun, the remaining lengths as the eastern. Many trigonometrical observations of peaks have been made in the western Kuen Lun, but our knowledge of the eastern range is confined to that gained by explorers, among whom Prejevalsky and Sven Hedin are pre-eminent.* East of longitude 86° the Kuen Lun is known as the Arka Tagh.

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* For map, see Holdich's *Tibet the Mysterious.* In the frontispiece chart of Part I the axis of the central Kuen Lun has been drawn too far north. In longitude 84° the axis should have been placed in latitude 36.° Chart XXXV repeats this mistake. Chart XXIII is correct.

The north-eastern portion of Tibet consists of the high level plains and basin of Tsaidam, which are bounded on the south by the Kuen Lun, on the north-west by the Altyn Tagh, and on the north-east by the Koko Nor range. The Altyn Tagh was discovered by Prejevalsky; it is a precipitous range, and portions of it rise above the line of perpetual snow. The easterly prolongation of the Altyn Tagh is the great range of Nanshan, considerable lengths of which rise also above the snow-line. The principal peaks of the Altyn Tagh are Anambarula, Amuninoku, and Koukye, all of which probably surpass 19000 feet in height. Both the Altyn Tagh and its continuation the Nanshan appear to be wide folds with minor corrugations superposed. The Koko Nor range of Tsaidam is parallel to the Nanshan, and the trough between them is over 300 miles long, the lake of Koko Nor being situated at its eastern extremity.

The Altyn Tagh.

As the Kuen Lun passes from Tibet eastwards into China, it loses the form of a great continuous fold and breaks up into minor ramifications, as the Hindu Kush does in Afghanistan. There is however this difference, that whereas the Hindu Kush does not split up into secondary folds, until it has emerged from the high plateau and descended to lower levels, the Kuen Lun begins to throw off its branches before it has left Tibet. Eastern Tibet is very intricate, no surveys have been made, and it is not possible at present to analyse the mountains from existing data, or to determine the relations of the Kuen Lun to the numerous ranges that traverse western China between the Hoang Ho and Yangtze rivers.

Easterly termination of the Kuen Lun.

From Prejevalsky's descriptions the Kuen Lun appears to bifurcate at its eastern extremity into two ranges, the Burkhan Buddha and the Shuga.*

" The Burkhan Buddha," he wrote, " is a distinct range more particularly on the " north, where it rises boldly from the perfectly level plains of Tsaidam : it has no very " conspicuous peaks, but extends in one unbroken chain."

" The ground gradually rises to another range the Shuga, lying parallel with the " Burkhan Buddha and terminating as abruptly on the west, where it abuts on the " Tsaidam plains.† About 70 miles to the south of the Shuga range rises a third " chain of mountains called by the Mongols Baian Kara Ula : they are situated on the " left bank of the head waters of the Blue river, called by the Mongols Murui-ussu, and " form the watershed between its basin and that of the sources of the Hoang Ho."

" Between the Shuga and Baian Kara Ula chains lies a terrible desert 14500 feet " above the level of the sea."‡

The Baian Kara Ula range is an eastern extension of the Kokoshili range of Tibet, which will be described subsequently.

The Kuen Lun does not form the water-parting between the Hoang Ho and Yangtze. The most westerly source of the Hoang Ho is in the interior of Tibet and *south* of the

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* N. Prejevalsky : *Mongolia,* Vol. II, page 175.

† *Idem,* page 178.

‡ *Idem,* page 180.

Kuen Lun; a feeder of the Yangtze drains the southern slopes of the Kuen Lun west of the Hoang Ho's source.*

The Kashgar and Sarikol ranges.

The Kashgar and Sarikol ranges are two parallel mountain chains that form the

The Kashgar range. eastern flank of the Pamir plateau, and that trend from south-south-east to north-north-west (frontispiece to Part I). The more easterly of the two is the Kashgar range, called by Humboldt the Bolor and by Hayward the Kizil-Art. It rises like a wall from the Tarim deserts, and is surmounted by glaciers and snow-clad peaks.

The Kashgar range is shown on the chart as a direct continuation of the Kuen Lun on the high authority of Stoliczka, but its connection with the Tian Shan is not understood (chart XVII).

North of the Kungur peaks (table IV, Part I), the Kashgar range appears to bend towards the north-west; at its bend it bifurcates, and throws out a branch range on the convex side of the bend. The Gaz river cuts through the range at the bifurcation a few miles north of Kungur. From its crest to its easternmost flank, where its further continuation is buried under sand, the Kashgar range is 60 miles wide.†

The Sarikol range, running parallel to the Kashgar on the west and at a distance of

The Sarikol range. 30 or 40 miles from the latter, is the lower range of the two, and its peaks do not reach 20000 feet. Nevertheless it is a primary water-parting of Asia, its western slopes draining into the Oxus and sea of Aral, its eastern into the Tarim river and lagoons of Lob Nor. The Sarikol range separates the Taghdumbash Pamir from the Little Pamir, and is crossed by the Nezatash (14915 feet), the Uzbel (15200 feet), and other passes.

The connection between the Sarikol and Aghil ranges is conjectural (frontispiece to Part I).

The trough enclosed between the Kashgar and Sarikol ranges is known as the Sarikol valley; it extends from the Taghdumbash Pamir to the little Kara Kul lake. "The valley of Sarikol," writes Sven Hedin, "is a gigantic trench piercing to the "heart of the stupendous Pamir plateau." The plains of the Taghdumbash Pamir form a southern continuation of the Sarikol valley; and the plains of Tashkurgan and of Tagharma are in the valley itself.

The Tashkurgan river drains the Taghdumbash Pamir and the northern slopes of the Hindu Kush, and passes into the Sarikol valley: in the valley it bends at right angles and piercing the Kashgar range escapes through a precipitous gorge to the plains of Tarim. The northern portion of the trough between the Sarikol and Kashgar ranges is drained by the Ulu-Art and Ikebel-su rivers, which unite and force a passage through the Kashgar range at the Gaz defile.

The Kashgar and Sarikol ranges thus constitute a system similar to that of the Hindu Kush and to that of the Great Himalaya. The Great Himalaya is higher than

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* On chart XVII the name of the Chinese river was spelt Huang; the new edition of the Imperial Gazetteer spells it Hoang Ho.
† Map to illustrate Younghusband's explorations, 1 inch 16 miles.

the Ladak range, but the latter is the water-parting, and its drainage cuts across the former through deep gorges. The same phenomenon is witnessed in the Hindu Kush; the southern range is the higher but the northern is as a rule the water-parting. Now again we see the Kashgar range higher than the Sarikol and yet pierced by the drainage of the latter.

The chart XVII was drawn primarily to illustrate the apparent clash of the Great Himalayan alignment with the Hindu Kush on the **The northern termination of the Kashgar range.** north-west and with the Arakan ranges on the east, but it has been made to include the clash of the Kashgar and Tian Shan ranges. East of the Brahmaputra we find the Great Himalaya trending perpendicularly to the Arakan chains; at the Indus we see the same giant range advancing at right angles to the Hindu Kush. And now to the north we have the Kashgar range running perpendicular to the Tian Shan. Just as we ask ourselves what has become of the Himalaya beyond the Brahmaputra and the Indus, so are we unable in Turkistan to decide how the Kashgar range has ended. The forces, that create ranges, are so powerful compared with those that are available for our experiments, that we cannot calculate the probable results of their action even under given conditions. What would now be the effect on the Himalaya if the earth's crust were compressed between Afghanistan and China, and if wrinkles like the Hindu Kush and the Arakan mountains began to advance from the west and the east against the ends of the established range? Would the axis of the latter be crumpled in plan into horizontal sinuosities, or would it be forced into an uniform curve, or would its ends be bent and crushed? These are questions we are unable to answer.

The Tian Shan ranges. [*]

The Tian Shan mountains are a complex system of ranges. They appear to be a broad crustal fold, the surface of which has been wrinkled into minor folds by forces acting from different directions. Severtsoff writes of the Tian Shan as "a system of "intersectional ranges:" the predominant ranges, he thinks, trend from east-north-east to west-south-west. [†]

Prince Kropotkin writes, that the two main directions of mountains in the Tian Shan are, firstly, from south-west to north-east, and, secondly, from south-east to north-west. [‡]

The axial line of the Karakoram range has been shown to trend from south-east to north-west and to bend round into the Hindu Kush, which runs from north-east to south-west. A remarkable parallelism, therefore, exists between ranges situated north and south of the mountain knot, known in geography as the Pamir plateau.

Of the Tian Shan ranges that run from south-east to north-west the Kugart range is perhaps the best known: of the ranges that run from south-west to north-east there are

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[*] *Vide* Tian Shan plateau, page 68 of this paper.

[†] *Journal, Royal Geographical Society*, Vol. XL, 1870.

[‡] *Geographical Journal*, Vol. XXIII, 1904.

the Alai and the Trans Alai, as shown on the frontispiece to Part I, and then south of Issik Kul there are the Terek range on the north, the Koktan in the centre, and the Artush bordering the Kashgar plains. The great lake of Issik Kul (height 5300 feet) lies north of the Terek range and is itself bounded on the north by the two granite ranges of Alatau.

At one time it was believed that no sedimentary rocks existed in the Tian Shan, but Semenoff showed that this idea was incorrect, and now Merzbacher writes, that the most elevated region of the Tian Shan is built up exclusively of sediment..ry rocks.

The great peak of the Tian Shan is Tengri Khan (23600 feet, *vide* table VI of Part I) ; the height of its summit surpasses all other peaks of the region by 3000 feet.* Many of the crests of the Tian Shan are above the line of perpetual snow, and it is probable that several peaks of 20000 feet exist on the central ranges. The outer ranges do not carry peaks above 16000 feet.

The outer ranges of the Himalaya enclose longitudinal valleys known as " duns,"
The " duns." but such valleys are not found in the Kuen Lun. On the southern flank of the Tian Shan they occur in places. " A " peculiar feature," wrote Stoliczka, " in this part of these hills consists in the occurrence " of extensive plains, to which the name ' jilga ' is generally applied. It means origi- " nally, I think, merely a water-course, and on a large scale these plains may be looked "upon as water-courses of former water-sheets. They occur at the base of the " high range, and in some respects resemble the ' duns ' of the southern slopes of the " Himalaya. North of Tangitar one of these large plains occurs within the lime-stone " rocks, being surrounded by them on all sides. It must be about 30 miles long from " east to west, and about 16 from north to south."†

Professor Ellsworth Huntington writes : " Apparently the Kashgar basin has long " been growing smaller by a process of continuous folding along the edges."‡

In his *Central Tian-Shan Mountains*, however, Merzbacher gives a different descrip- tion of the outer hills : the latter he describes as "subsiding gradually in ranges of " transverse spurs, whose cape-like ends project far into the desert." " Much of the " outermost skirting range," he says, " lies buried in the enormous rubbish heaps of " the high plain. The hitherto prevailing conception of the wall-like descent of the " range must be given up."

At their eastern extremity the Tian Shan are separated from the Altai mountains of Mongolia by the remarkable depression known as the Zungarian strait, 2300 feet high : on the west they end in the Alai and Trans Alai ranges.

The Trans Alai range is the snow-clad chain, which borders the Pamir plateau on the
The Trans Alai. north : it is a very important range and surpasses in height all the mountains that intersect the Pamir plateau itself. Kaufmann (23000 feet) is its highest peak ; the pass of Kizil-Art crosses it at a height of 14260 feet.

* Merzbacher : *Central Tian-Shan Mountains*, 1905.

† T. D. Forsyth : *Report of a Mission to Yarkand*, 1873, page 472.

‡ Compare this, however, with our preceding note on the Kuen Lun in which we come to the conclusion that outer ranges are absent.

The Alai range is north of the Trans Alai and lower; its average elevation does not exceed 16000 feet, and its highest peaks rise only to 19000 feet. There are several passes crossing it at 12000 feet.

The Alai.

The trough between the two ranges is known as the Alai valley; it is crossed by the water-parting between the Aral and Tarim basins, the drainage of its eastern portion flowing one way, that of its western the other. The height of the trough at the water-parting is 11000 feet; the surface of the trough has gentle slopes, and the actual water-parting is not a marked feature. The two rivers flowing eastwards and westwards from the water-parting of the Alai valley are both named Kizil-su.

18

THE RANGES OF THE INTERIOR OF TIBET.

A complete history of the exploration of Tibet will be found in Sir Thomas Holdich's *Tibet the Mysterious.* Chart XXII of this paper illustrates the tracks of explorers over the interior of Tibet.

Many parallel mountain ranges have been found to exist, but their number and positions and heights are not at present known.

Between the Kailas and Kuen Lun ranges there are probably at least five primary ranges, and of these the prolongation of the Karakoram fold is probably one. We have observed the continuity of the Great Himalaya, and of the Kailas and Ladak ranges in Southern Tibet; and explorers have traced the Kuen Lun on the north of Tibet from west to east. It is probable, then, that the central folds will also be found continuous; they may bend in places, and subside in others; they may bifurcate and conjoin; and different lengths may appear to overlap; but the primary folds probably do continue from Afghanistan to China.

Many explorers have emphasised the fact, that the interior ranges of Tibet and their intermediate troughs trend from west to east.[*] Nain Singh followed a long west and east trough containing a continuous series of lakes: Bower followed another, and Sven Hedin a third. The large rivers of central Tibet appear to flow in west and east directions.

" Like all the previous lakes," wrote Sven Hedin in northern Tibet, "lake No. 18 " had an east and west direction, and was one of the largest we encountered; we travel- " led beside it the whole of the day (sixteen and three-quarter miles)."

The explorer Kishen Singh traversed Tibet from south to north, from Lhasa to Saichu, and crossed over several ranges: the following are extracts from the narrative of his journey in the interior of Tibet:—[†]

(i) " We reached the Lani La pass by an easy ascent of $2\frac{1}{4}$ miles. The Lani La " range comes from the east, and far off in that direction are some high " peaks covered with perpetual snow."

(ii) " Tangla is a long range of mountains running from the west and possess- " ing several snowy peaks and spurs."

(iii) " The Dungbura Khuthul pass has an easy ascent. The general direc- " tion of the long range bearing this name is from east to west."

(iv) " We crossed the Kokoshili Khuthul pass which has an easy ascent. " The general direction of the range is from east to west."

(v) " A steep ascent of $1\frac{1}{2}$ miles then brought us to the Angirtakshia Khuthu " pass. The Angirtakshia, a long range, lies east and west."[‡]

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[*] Littledale's evidence does not support this view; he marched southwards from the Kuen Lun (latitude 36° 5′) to Tongri Nor (latitude 30° 40′). " We never," he wrote, " saw a single continuous mountain range, till we came to the Ninchin- " thangla."

[†] J. B. N. Hennessey: *Report on the explorations in Great Tibet and Mongolia made by A-K in* 1879-1882.

[‡] Angirtakshia is a local name for an easterly extension of the Kuen Lun.

The Ninchinthangla range, however, trends from north-east to south-west and forms a very striking exception to the east and west rule (frontispiece to Part I).

If we examine the frontispiece to Part I we see that the meridian of 92° crosses four ranges in Tibet ; of these that situated north of latitude 30° is the Lani, that north of 31° is the Ninchinthangla. The Tangla is near latitude 33° and the Kokoshili is north of 35°. Kishen Singh's Dungbura range, which has not been shown on the chart, runs north of 34° between the Tangla and the Kokoshili.

On the west of Tibet we find between the Kailas and the Kuen Lun ranges two primary ranges, the Karakoram and the Aghil : on the east we find five, the Lani, the Ninchinthangla, the Tangla, the Dungbura and the Kokoshili. Two ranges are thus known to enter the interior of Tibet from the west, five have been observed to issue from it on the east. How the two become five, or whether there are not more than five we do not know.

When Wellby travelled in 1896 from west to east through northern Tibet he marched south of the Kokoshili range for a long distance.

The Kokoshili. Sven Hedin explored the long trough to the north between the Kokoshili and Kuen Lun. In longitude 94° 20' the Kokoshili is cut through by a northern affluent of the Yangtze, but east of the gorge it becomes, under the name of Baian Kara Ula, the water-parting between the Hoang Ho and Yangtze.

Wellby's "Abrupt" peak and the "King Oscar" peak of Sven Hedin rise from this range.

The Tangla range forms the water-parting in Tibet between the Yangtze and Salween, and Prejevalsky traced an affluent of the

The Tangla. former almost to its source in the Tangla at a height of 16400 feet.

The Ninchinthangla range forms the water-parting between the Brahmaputra and the closed basin of Tibet. Mr. and Mrs. Little-

The Ninchinthangla. dale crossed this range by the Goring pass (19587 feet), and the explorer Nain Singh crossed it by the Khalamba pass (17200 feet). Little-dale described the Ninchinthangla as " a magnificent range—a succession of snow-clad " peaks and glaciers." "Above all," he wrote, " towered with cliffs of appalling " steepness the great peak of Charemaru, 24153 feet. From this point of view it was " perhaps one of the most impressive mountains I had ever seen.*" Colonel Montgomerie wrote : " To the south the lake is bounded by a splendid range of snowy peaks flanked " with large glaciers, culminating in the magnificent peak Jang Ninchinthangla which " is probably more than 25000 feet above the sea. The range was traced for nearly " 150 miles running in a north-easterly direction."†

In a table below we give a list of all the highest peaks of Tibet, the positions of which are known : we are unable to identify either Montgomerie's peak Jang Ninchin-thangla or Littledale's Charemaru : the two were possibly the same peak.‡ In 1904

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* *Geographical Journal*, Vol. VII, 1896.
† Colonel Montgomerie's Memorandum on the exploration of the Nam Tso or Tengri Nor Lake, 1873-74.
‡ For Ryder's note on Bonvalot's peaks see *Report on Survey operations with the Tibet Frontier Commission*, 1904

Major Ryder fixed several peaks of the Ninchinthangla range from the neighbourhood of Lhasa. R²¹⁷ was the highest peak he observed, and its altitude was 23255 feet. It is unlikely that Montgomerie's or Littledale's peaks are higher than this.

The Lani range is an easterly branch of the Ninchinthangla.

Nothing is known of the Dungbura range beyond the fact that Kishen Singh crossed it.

The prolongation on the frontispiece to Part I of the Karakoram range and its

Prolongation of the Karakoram in Tibet.

conjunction in longitude 92° with the Ninchinthangla are hypothetical. We do not yet know that the Karakoram range does continue eastwards through Tibet, and even if it be proved to do so, it may be found to connect with the Tangla range north of latitude 32°, and not with the Ninchinthangla. Observers of the Himalaya, the Ladak and the Kailas ranges have been impressed with their apparent continuity, and it is perhaps natural that we should seek for the prolongation of the gigantic Karakoram : the prolongation, however, as entered on the chart, is intended to suggest only the *possibility* of continuity, and must not be accepted as fact.

The following extracts show the evidence upon which the drawing of the Karakoram range in the chart has been based : —

" A number of lofty snowy peaks were determined from various stations of the " route survey, the most remarkable being the Aling Kangri group north of the Indus, " which, judging from the great mass of snow seen on its southern face during August " and September, must be upwards of 23000 feet above the sea, possibly as much as " 24000 feet. The line of perpetual snow on the southern slopes of the Ladak " Mountains approximates to 20000 feet in the same latitude, and it would require " several thousand feet of snow above that line in order to be very imposing at 80 " miles, at which distance the Pandit first saw it. The Aling Kangri group had never, " as far as I am aware, been heard of before. They appear to be a continuation of " the range between the Indus and the Pangong lake."*

" The Pandit Nain Singh left Leh in July 1874 and succeeded in crossing the " Tibetan frontier in the disguise of a Lama or Buddhist priest. Passing about 15 " miles to the north of Rudok, he travelled nearly due east for a distance of more than " 800 miles over a new line of country, separated from the valley of the Sangpo " (Brahmaputra) by an almost continuous range of snow mountains, which trends east- ' wards, from the Aling Kangri peaks in longitude 81°, up to the Ninchinthangla peaks "in longitude 90½°."†

In central Tibet the line of perpetual snow does not lie much below 20000 feet, and the fact that Nain Singh saw snow extending almost continuously from longitude 81° to 90½° is evidence of the existence of a great range.

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* Colonel Montgomerie's *Report on Trans-Himalayan Explorations*, 1867. The range between the Indus and the Pangong lake is the Ladak range : possibly the Kailas range also passes between. The Aling Kangri peaks are now believed to stand considerably north of the Kailas and Ladak ranges, and to mark perhaps the continuation of the Karakoram.

† An account of Trans-Himalayan explorations by General J. T. Walker, R.E., F.R.S. *General Report, Great Trigonometrical Survey of India*, 1874-75, page 20.

The question may be asked whether the snowy range seen by Nain Singh to the south may not have been the Kailas range: the answer is that the snow peaks fixed by Nain Singh stand 120 miles north of the Brahmaputra and many miles north of any known peaks of the Kailas range. Thus the Aling Kangri peaks east of longitude 81° are a hundred miles north of the sacred peaks of Kailas. In longitude 85° the two ranges are one hundred miles apart and in 86° eighty miles. The interval in fact between Nain Singh's range of peaks and the Kailas range is greater than between the Kailas and Ladak ranges, and if we have regard to the spans of the known ranges of the Himalaya and Karakoram, we find it more reasonable to assume that an intermediate trough separates Nain Singh's range from the Kailas than that the two apparent chains of mountains are the respective flanks of one broad range.

The following extract from Captain Trotter's report on the Trans-Himalayan explorations of 1873-74-75 gives further details of Nain Singh's journey :—

Four hundred miles east of Aling Kangri "the Pandit encountered a lofty " range of mountains, which was crossed by a high but easy pass called Kilong, 18170 " feet above sea-level. This range runs southwards and culminates in some enormous " peaks known by the name of Targot, from which extends eastwards a snowy range, " numerous peaks of which were fixed by the Pandit along a length of 180 miles " up to where the range terminates in a mass of peaks called Gyakharma, which also " lie to the south of and very near the Pandit's road. The highest of these Gyakharma " peaks was ascertained by measurement to be 22800 feet above sea-level, and the " Pandit *estimates* that the highest of the Targot peaks, which lay too far off the road for " vertical measurement with a sextant, is at least 2500 feet higher ".*

" This range is probably not the watershed between the basin of the Brahma- " putra and the lake country of Tibet, for the Pandit was informed that to the south " of the range, running parallel to it, is a large river, the Dumpho or Hota Sangpo " which ultimately changes its course and flows northwards into the Kyaring lake."

" Thus far on his journey," continues Captain Trotter, " the Pandit states that " a cart might be driven all the way from Noh without any repairs being made to " the road, but in crossing the range the path was steep and difficult. There is an " alternative road, however, lying to the north, by which it is said a cart might " easily travel to the Nam Tso lake without meeting a single obstacle *en route*."

" The height of the plateau traversed appears to vary but little between 15000 " and 16000 feet above the sea-level. The plain is as a rule confined between moun- " tains which run parallel to the direction of the road, but a few transverse ridges " of considerable elevation are crossed *en route*."

The following table gives a list of the high peaks of Tibet, as known to us, and shows the ranges on which they stand. A few of the heights such as those of Leo Pargial, Kamet, Kailas and Gurla Mandhata have been well determined and may be ranked as values of the first class in accuracy : many heights, however, which have been

---

* Estimates of heights of snow peaks have so often proved to be in error by 5000 or 6000 feet, that no weight what-ever is now attached to them.

measured trigonometrically from stations in Tibet, can only be regarded as belonging to the second class of accuracy, owing to the uncertainty attaching to the altitudes of the points from which the observations were taken. The sextant observations of Nain Singh furnish heights of the third class of accuracy, whilst his numerical estimates of Aling]Kangri, Targot Yap, and Samdankang Jang can only be accepted as indications of imposing[height. ; The explorer Kishen Singh contented himself with recording against Jhomogangar "very high", and refrained from numerical estimation.

TABLE XXVII.—The high peaks of Tibet.

NOTE.—Peaks of the Himalaya, Karakoram and Kuen Lun ranges have been excluded, as this list is intended to show peaks that stand in the interior of Tibet.

Range.		Name.	Height in feet.	Latitude.	Longitude.*	Authority.
				o ′ ″	o ′ ″	
Zaskar	{	Leo Pargial S. .	22170	31 53 5	78 44 5	} Great Trigo-
	{	Leo Pargial N. .	22210	31 54 8	78 44 39	} nometrical
	{	Kamet . . .	25447	30 55 13	79 35 37	} Survey.
Ladak	⎰	Gurla Mandhata .	25355	"0 26 18	81 17 57	G. T. Survey.
		W167 . . .	20751	30 13 46	82 8 5	⎱
		W168 . . .	21007	30 14 25	82 8 38	
		W156 . . .	21431	30 17 8	82 8 53	
		W166 . . .	21383	30 9 37	82 9 41	
		W144 . . .	22032	30 7 26	82 11 17	
		W145 . . .	21568	30 12 35	82 11 28	
		W164 . . .	20467	30 1 50	82 19 36	
		W143 . . .	20168	30 0 44	82 21 51	
		W155 . . .	21754	29 51 0	82 42 16	
		W162 . . .	20684	29 47 57	82 43 23	} Wood.
		W154 . . .	22492	29 45 29	82 45 0	
		W153 . . .	21477	29 40 32	83 0 3	
		W161 . . .	20000	29 36 11	83 13 21	
		W159 . . .	20244	29 30 57	83 21 55	
		W124 . . .	20560	29 33 51	83 39 5	
		W89 . . .	20727	28 45 34	85 32 27	
		W90 . . .	21248	28 46 37	85 32 57	
		W77 . . .	21169	28 56 58	86 5 12	
		W48 . . .	21263	28 57 58	87 16 51	⎱
		R119 or N o j i n k a n g Sang	23600	28 57 2	90 11 1	⎰
		R121 . . .	21852	28 51 13	90 12 43	
		R122 . . .	21424	28 50 18	90 13 26	} Ryder.
		R123 . . .	20456	28 48 25	90 13 33	
		R289 . . .	21660	28 46 33	91 59 20	
		R289 (a) (Yala Shimbo of Nain Singh)	21768	28 47 46	91 59 20	⎱

* The values of longitude are based on the determination of the difference between Greenwich and Madras made in 1894-96, and are not those hitherto accepted by the Survey of India.

TABLE XXVII.—The high peaks of Tibet—*continued.*

Range.	Name.	Height in feet.	Latitude.	Longitude.*	Authority.
			° ′ ″	° ′ ″	
	W^{215}	20437	31 5 18	81 13 57	Wood.
	Kailas	22028	31 4 2	81 18 50	G. T. Survey.
	W^{135}	21600	29 55 16	84 33 33	⎫
	W^{134}	23150	29 50 4	84 36 39	⎬ Wood.
	W^{133}	21300	29 48 49	84 38 8	⎭
	W^{122}	20628	29 43 16	85 10 11	
Kailas	Harkiang	...	29 32 0	85 14 0	Nain Singh.
	W^{117}	20616	29 26 45	85 21 44	⎫
	W^{100} or Cho-ur-dzong	21300	29 27 43	85 23 8	
	W^{86}	20752	29 26 37	85 23 18	⎬ Wood.
	W^{88}	21097	29 29 25	85 24 52	
	W^{87}	21227	29 28 30	85 24 53	
	W^{60}	20000	29 33 25	87 8 38	⎭
	R^{273}	21439	29 20 56	91 45 42	Ryder.
These peaks stand on a range in Tibet that may possibly prove to be the continua t i o n of the Kara- koram.	Aling Kangri	24000	32 46	81 2	⎫
	Ning Kangri	..	32 15	83 0	⎬ Nain Singh.
	Shyalchikang Jang	Very high	31 45	84 45	
	Targot Yap	25000	30 40	86 15	
	Gyakharma	22800	30 50	88 30	⎭
	Jhomogangar	Very high	29 50 0	89 50 0	Explorer A.-K.
	R^{210}	22950	29 54 7	90 2 3	⎫
	R^{291}	20207	29 51 26	90 13 25	
	R^{216}	21694	30 18 9	90 29 7	
	R^{212}	20456	29 57 7	90 32 46	
	R^{217}	23255	30 22 17	90 35 19	
Ninchinthangla	R^{219}	20366	30 27 37	90 41 41	⎬ Ryder.
	R^{222} or S a m d e n Khansa of A-K	20576	30 47 55	91 25 54	
	R^{223}	21543	30 50 38	91 29 40	⎭
	†Samdankang'Jang	24000	30 50 0	91 30 0	⎫ Nain Singh.
	Potamolam	...	30 30 0	91 49 0	⎭
	P ^{24}	20130	30 30 33	91 52 9	Ryder.
Central Tibet	Kangdigar	20600	31 20 0	86 45 0	⎫ Nain Singh.
	Munza Kangri	...	32 20 0	87 15 0	⎭
North-Eastern Tibet . . .	Caroline	18000	35 20 0	97 30 0	Rockhill.

* The values of longitude are based on the determination of the difference between Greenwich and Madras made in 1894-96, and are not those hitherto accepted by the Survey of India.

† The *Samdankang Jang* of Nain Singh is probably identical with R^{223}: possibly the *Samden Khansa* of A-K is the same peak also, and not R^{222} as shown. The *Potamolam* of Nain Singh is probably identical with R^{224}. Nain Singh's value for the height of *Samdankang Jang* has been shown by Ryder to be over 2000 feet too great.

TABLE XXVII.—The high peaks of Tibet—*concluded*.

Range.	Name.	Height in feet.	Latitude.			Longitude.*			Authority.
					"	°	'	"	
Northern Tibet	Abrupt peak .	...	35	30	0	82	30	0	Wellby.
	Ullug Muztagh	24000	36	30	0	87	20	0	} Sven Hedin.
	King Oscar peak	...	35	30	0	87	40	0	
Western Tibet	Camp 74 peak 273 .	20010	33	58	3	79	40	28	
	„ 51 „ 170 .	20980	32	47	58	81	8	58	
	„ 51 „ 169 .	20730	32	47	10	81	12	10	
	„ 57 „ 185 .	20100	33	40	37	81	18	2	
	„ 109 „ 84 .	20370	34	32	49	81	33	9	
	„ 57 „ 179 .	20200	33	42	15	81	39	25	} Deasy.
	„ 51 „ 142 .	21020	33	26	56	81	42	31	
	„ 49 „ 144 .	20550	33	35	49	81	55	41	
	„ 51 „ 165 .	20180	33	26	30	82	12	57	
	„ 32 „ 116 .	20970	33	27	54	82	15	30	
	„ 29 „ 94 .	20100	33	58	45	82	17	6	
	„ 110 „ 103 .	20260	34	40	19	82	19	19	
	Peak 95 .	20350	33	49	4	82	19	32	Ram Singh.
	Camp 57 peak 162 .	20650	33	48	55	82	19	41	
	„ 110 „ 93 .	20750	34	44	20	82	20	49	} Deasy.
	„ 110 „ 94 .	20190	34	43	53	82	21	1	
	„ 51 „ 163 .	20820	33	46	38	82	21	11	
	Peak 89 .	20310	33	18	7	82	22	19	Ram Singh.
	Camp 110 peak 92 .	20640	34	46	33	82	22	12	} Deasy.
	„ 32 „ 89 .	20690	33	40	53	82	30	21	
	Snow Peak 34 .	20010	34	25	4	83	1	13	Ram Singh.
	Camp 32 peak 110 .	20480	33	16	24	83	5	18	
	„ 32 „ 109 .	20910	33	11	2	83	24	45	} Deasy.
	„ 32 „ 108 .	20120	33	15	33	83	29	9	

* The values of longitude are based on the determination of the difference between Greenwich and Madras made in 1894-96, and are not those hitherto accepted by the Survey of India.

19

THE LIMIT OF PERPETUAL SNOW.

The " snow-line " is the lower limit of perpetual snow—the line above which the snow resists the heat of summer, and below which it all disappears for a certain time every year. Snow will remain unmelted in deep ravines long after it has disappeared from neighbouring summits, but in determining the snow-line we have to consider not sheltered snow but snow exposed to the rays of the sun.

The snow-line is dependent upon temperature and snow-fall, and to a lesser degree upon wind. A light snow-fall renders the line high ; the temperature of air at the snow-line is always below the freezing point of water in regions of scanty snow-fall.

If snow-fall were everywhere uniform, the height of the snow-line would vary with temperature, and would consequently tend to decrease from the equator to the poles, as the latitude increased. It would, however, under such conditions, be slightly lower (north of the equator) on northern slopes than on southern, owing to the difference between the angles at which the sun's rays are inclined to the mountain surface.

On the southern slopes of the Great Himalayan range the snow-line is 3000 feet lower than on the northern : this large difference is mainly due to the southern slopes being exposed to damp winds from the Indian ocean, which drop their moisture before they cross the range. Tibet and the Tian Shan are extraordinarily dry, and their snow-lines are consequently higher than those of mountains situated in the same latitudes but in other continents. In western China and in the extreme east of Tibet a quantity of rain and snow falls, and the snow-line is low.

TABLE XXVIII.—Height of the snow-line in Central Asia.

Range.	Aspect.	Latitude.	Height of snow-line in feet.	Authority.
Nepal Himalaya	South	28°	14700	Hooker : *Journal, R. G. S.,* XX, 1851.
South-East Tibet	...	29°	13000	Gill : *Journal, R. G. S.,* XLVIII, 1878.
Kumaun Himalaya	South	30° 30'	15500	} Richard Strachey : *Journal, A. S. B.,*
Kumaun Himalaya	North	30° 30'	18500	} XVIII, 1849.
Punjab Himalaya	South	34°	17000	Montgomerie : *G. T. Survey Syn., Vol.* VII.
Punjab Himalaya	North	34°	19000	}
Zaskar	South	34°	20000	} Cunningham's *Ladak.*
Zaskar	North	34°	19500	}
Ladak range near Leh.	North	34°	18500	} Drew : *Jummoo and Kashmir territories.*
Ladak range near Leh.	South	34°	19000	}
Kailas	South	31°	19500	Richard Strachey : *Journal, A. S. B.,* XVIII, 1849.

TABLE XXVIII. —Height of the snow-line in Central Asia —*continued*.

Range.	Aspect.	Latitude.	Height of snow-line in feet.	Authority.
Western Tibet . .	...	31°	20000	Richard Strachey : *Encyclopædia Britannica, article Himalaya.* Drew : *Jummoo and Kashmir territories.* Deasy : *In Tibet and Chinese Turkistan.*
Karakoram . .	South	36°	18500	Cunningham's *Ladak.*
Karakoram . .	North	36°	18500	Hayward : *Journal, R. G. S., XL, 1870.*
Karakoram . .	North	36°	18000	Cunningham's *Ladak.*
Tian Shan . .	...	42°	11000	Semenoff: *Journal, R.G.S., XXXV, 1865.*
Alai . . .	...	40°	11000	Delmar Morgan : *R. G. S., Supplementary Papers, 1886.*
The snow-line in Europe and Western Asia.				
Pyrenees . . .	...	43°	8500	
Caucasus . . .	...	43°	10000	
Alps . . .	...	46°	8500	

Twenty thousand feet is the highest elevation to which the snow-line has been observed to recede, and it is probable that it will be nowhere found higher : the snow-lines on the Kuen Lun and in central Tibet have never yet been determined, but they are estimated to lie lower than that of western Tibet, which is one of the driest regions of the earth.

We do not know at present to what extent the rainfall or snow-fall varies with height, nor have we been able to determine the elevation of maximum precipitation. Sir Joseph Hooker doubted whether the winds from the Indian Ocean ever reached the summit of Kinchinjunga, and he thought that very little snow fell at that great height.*

The outer Himalayan ranges everywhere intercept a large part of the rainfall from the Indian Ocean ; the Pir Panjal range, for example, prevents the moisture-laden winds from reaching the valley of Kashmir. But the snow covering the Great Himalaya shows that there are damp currents at high altitudes, which are prevented by the range from entering Tibet.

The water in the lakes of western Tibet is due not to rain falling on the high plains but to snow accumulating on the ranges and descending in glaciers.

" The height," wrote Richard Strachey, " at which it is certain that snow will fall " every year in this region (Kumaun) of the Himalaya, is about 6500 feet, and at an " elevation of 5000 feet it will not fail more than one year out of ten. The least height " to which sporadic falls of snow are known to extend is about 2500 feet, and of such " falls there are only two authentic instances on record, since the British took possession " of Kumaun, *viz.*, in 1817 and 1847."†

Snow was observed to be falling on one occasion, at 10 o'clock at night, in February, 1906, in Dehra Dun, at a height of 2400 feet.

* *Himalayan Journals.* Vol. II, page 390.
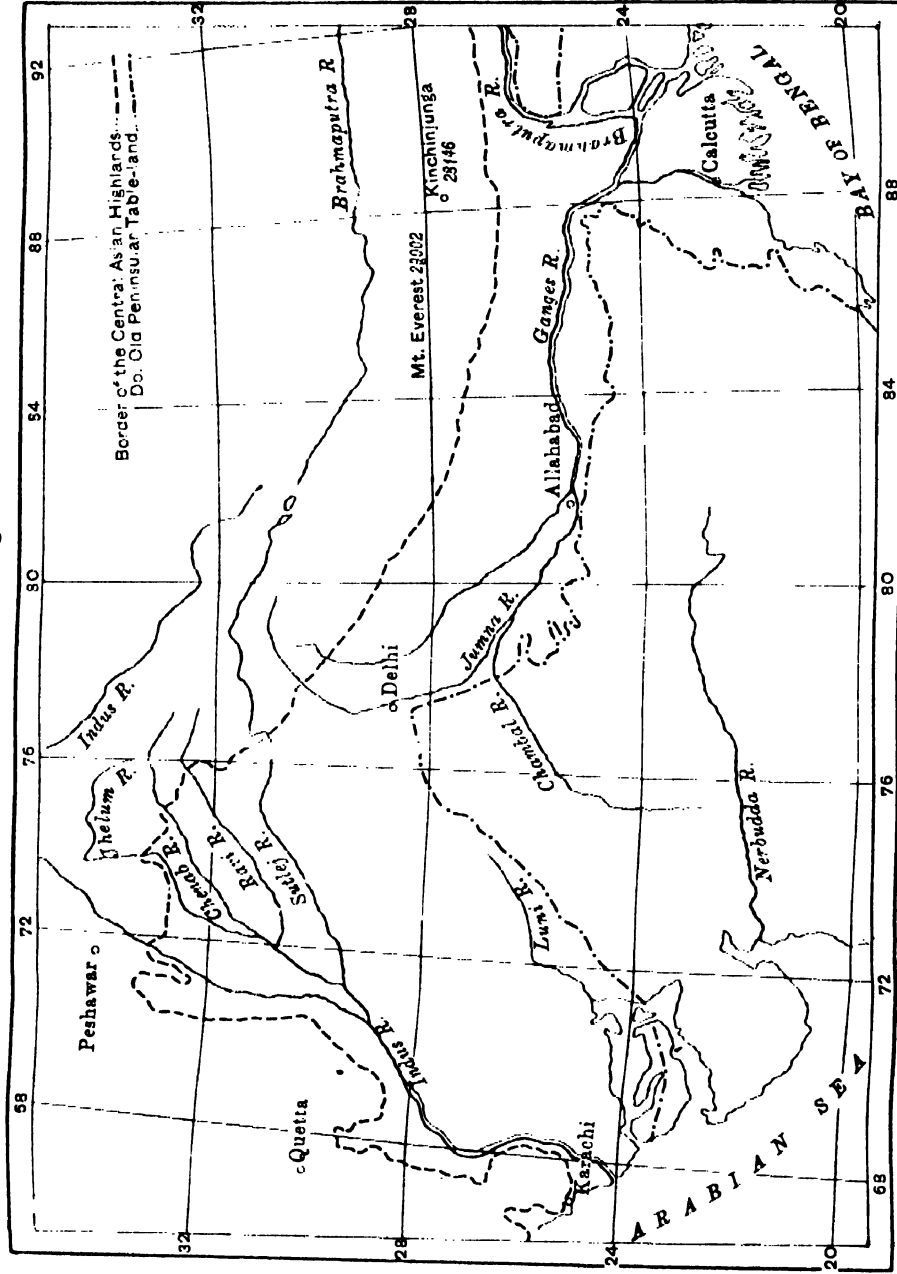† *Journal, Asiatic Society of Bengal,* Vol. XVIII, 1849.

Chart

illustrating the PARALLELISM

between the borders of

the old Peninsular Table-land and

the Central Asian Highlands

CHART IX
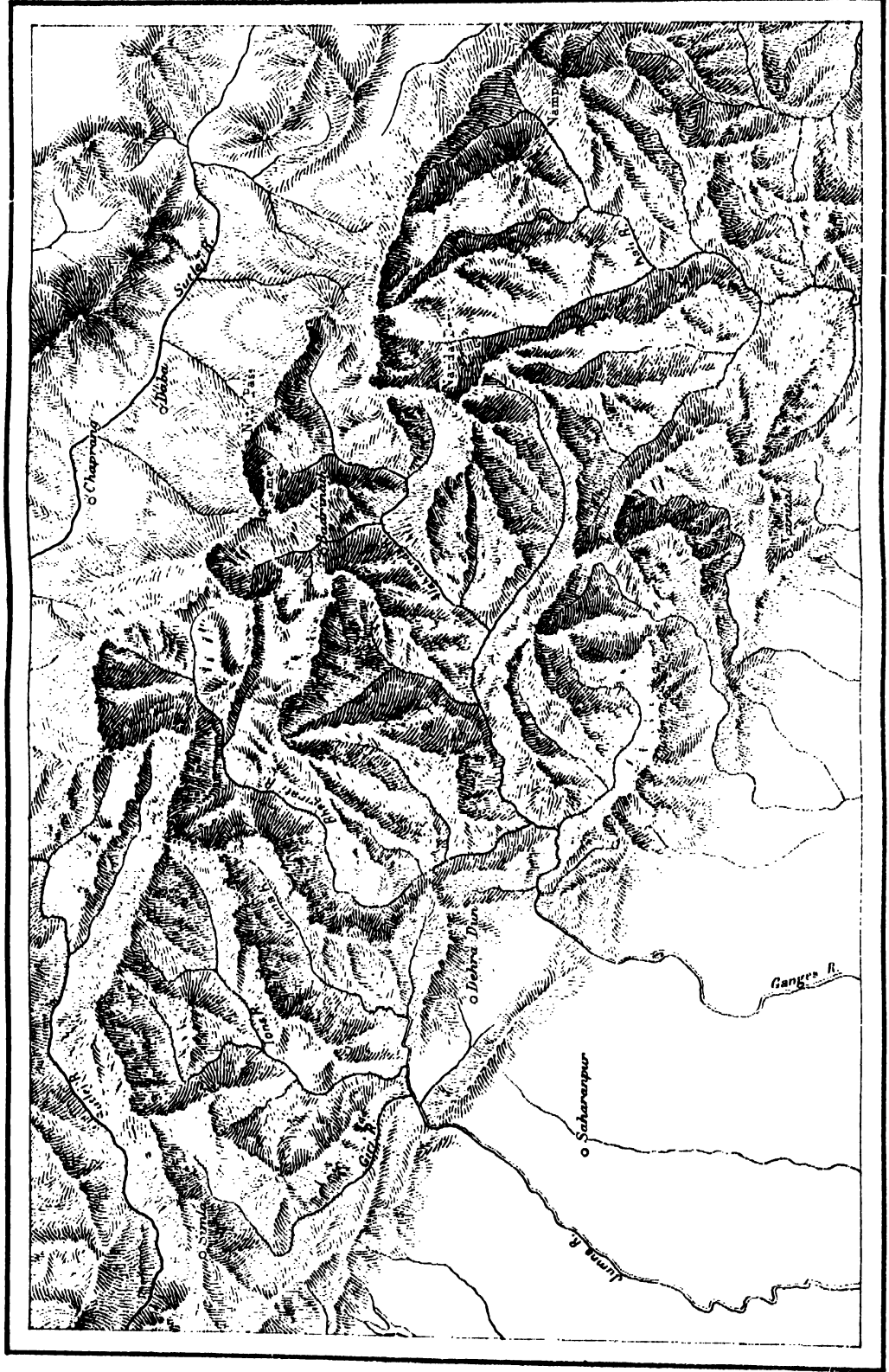

Border of the Central Asian Highlands ......
Do. Old Peninsular Table-land. ......

Indus R.

Jhelum R.

Chenab R.

Ravi R.

Sutlej R.

Peshawar

Quetta

Indus R.

Karachi

Luni R.

Chambal R.

Jumna R.

Delhi

Allahabad

Ganger R.

Mt. Everest 29002

Kinchinjunga
29146

Brahmaputra R.

Brahmaputra R.

Calcutta

Nerbudda R.

ARABIAN SEA

BAY OF BENGAL

CHART X

THE

KUMAUN HIMALAYA

AS REPRESENTED ON THE 32 MILE MAP OF INDIA.

Sutlej R.

Bispurie C.

Ghola

Ganges R.

Dehra Dun

Saharanpur

Jumna R.

THE KUMAUN HIMALAYA
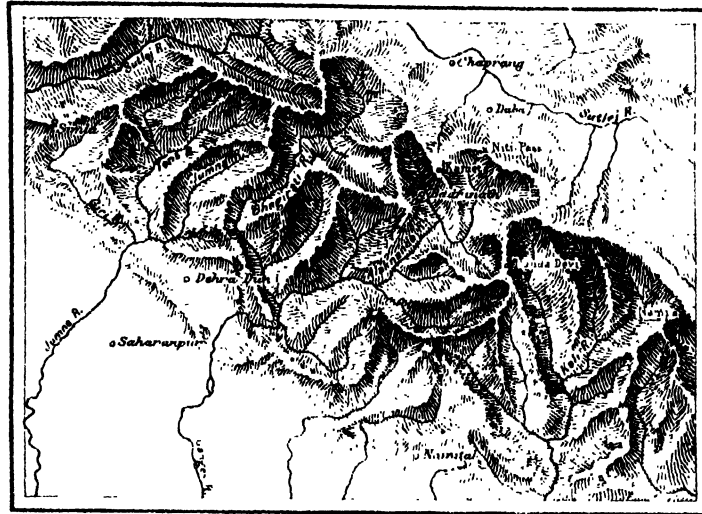
DRAWN ON THE 64 MILE SCALE IN ACCORDANCE
WITH THE GENERALIZATIONS OF THIS PAPER.
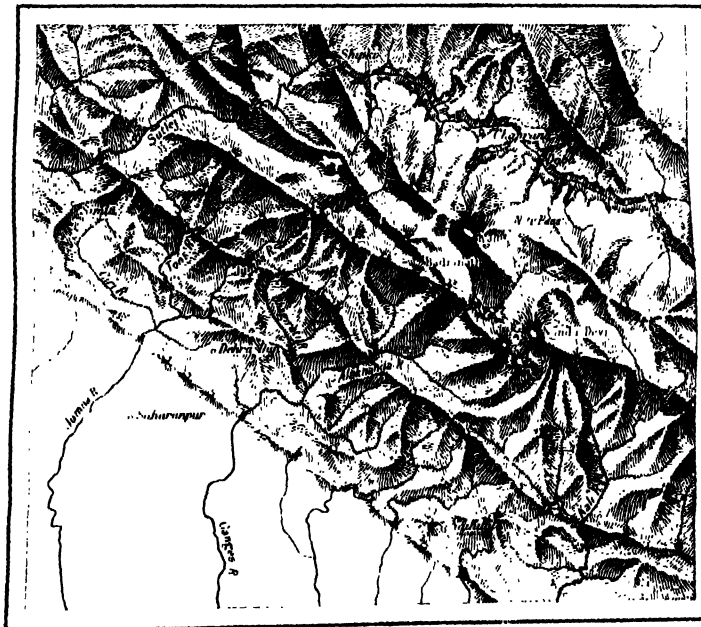
CHART XII

Diagram to illustrate

Brian Hodgson's theory of

HIMALAYAN CONFIGURATION

1848

Jamnotri

Nanda Devi

Dhav'agiri

Gosainthan

Kinchinjunga

The Ganges

The Karnali

The Gandak

The Kosi

The Tista
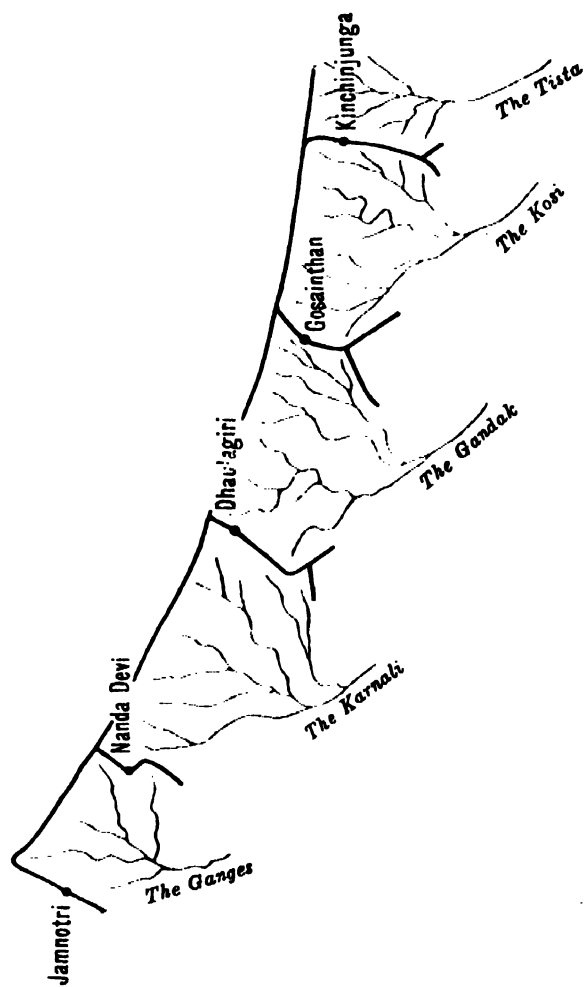
CHART XIII .

SECTION
along the GREAT RANGE of the HIMALAYA
from the INDUS to the TISTA
showing how it is being cut
by the rivers into isolated blocks

Line showing
height of
20000 feet

Indus River
Nanga Parbat
Kamri Pass
Zoji Pass
Sar or Nana
Baralacha Pass
Feeders of the Sutlej
Sutlej River
Ganges River (Bhagirathi)
Gangotri
Kedarnath
Badrinath
Ganges River (Alaknanda)
Nanda Devi
Kali River (Gori)
Kali River (Dharma)
Kali River
Api
Line showing
height of
20000 feet

Sea Level
Sea Level

Miles
from Indus

0   100   200   300   400   500   561 Miles
from Indus

----------PUNJAB HIMALAYA----------   ----------KUMAUN HIMALAYA----------

But few peaks exceed 21000 feet. The water-parting coincides with the main Range.

Many peaks exceed 22000 feet.

The water-parting is situated 20 or 30 miles behind the main Range.

Line showing
height of
20000 feet

Api
Karnali River
Feeders of the Karnali
Karnali River (Bireh)
Dhaulagiri
Kali Gandak River
Madi River
Burhi Gandak River
Trisuli Gandak River
Bhotia Kosi River
Dudh Kosi River
Everest
Arun Kosi River
Tambar Kosi River
Kinchinjunga
Tista River
Chumalhari
Line showing
height of
20000 feet

Sea Level
Sea Level

Miles 561
from Indus

600   700   800   900   1000   1100   1125 Miles
from Indus

----------NEPAL HIMALAYA----------

Many peaks exceed 25000 feet. The water-parting is situated 50 or 60 miles behind the main Range.

SCALES

Vertical

Feet 40000   20000   0   40000 Feet

Horizontal

Miles 64   48   32   16   0   64   128 Miles

EIGHT CROSS SECTIONS of the HIMALAYA
## drawn at right angles to the Great Range
Cross-Sections 1 to 4.

CHART XIV

No. 1 THROUGH KASHMIR AND K².
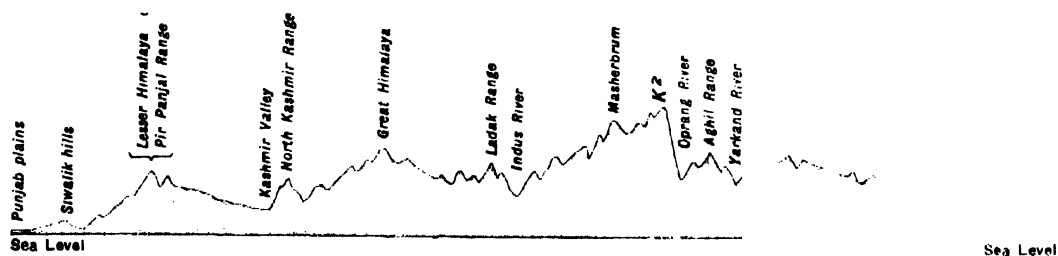
No. 2 THROUGH KANGRA AND WESTERN TIBET.
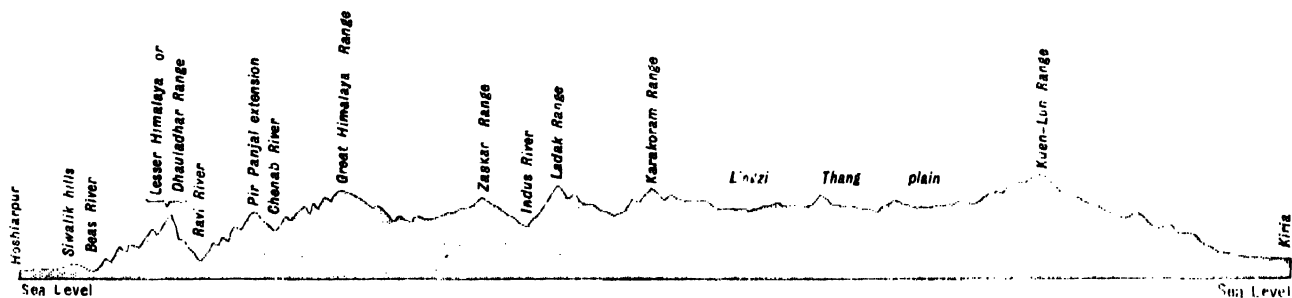
No. 3 THROUGH NANDA DEVI.
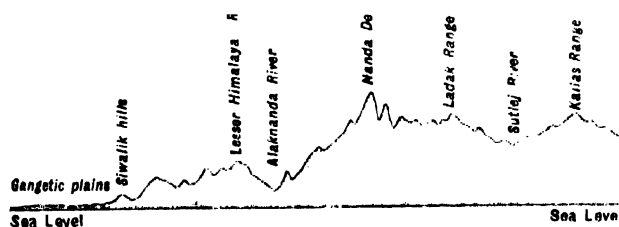
No. 4 THROUGH DHAULAGIRI.

EIGHT CROSS SECTIONS of the HIMALAYA

CHART XV

drawn at right angles to the Great Range
Cross-Sections 5 to 8.

No. 5 THROUGH GAURISANKAR.
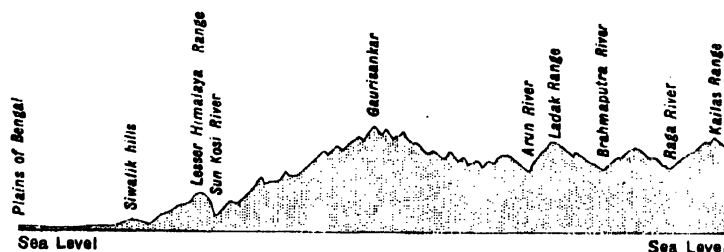
No. 6 THROUGH MOUNT EVEREST.
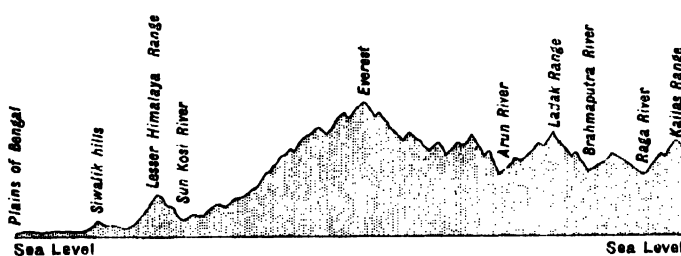
No. 7 THROUGH KINCHINJUNGA.
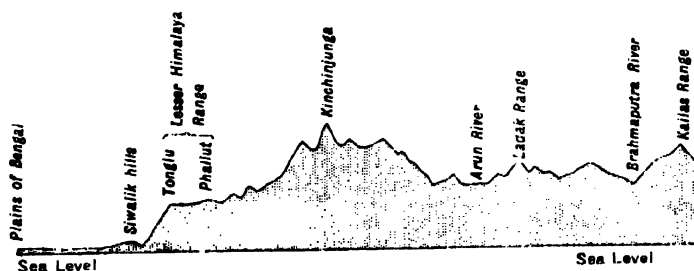
No. 8 THROUGH THE ASSAM HIMALAYA.

CHART XVI

BIFURCATIONS
of the
GREAT HIMALAYA RANGE.
Scale 1″ = 32 Miles
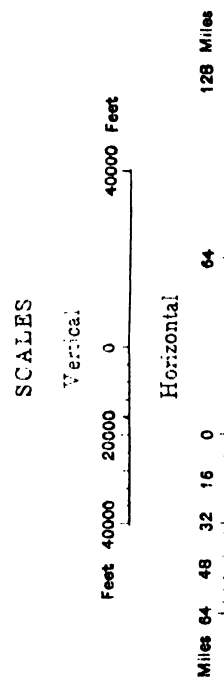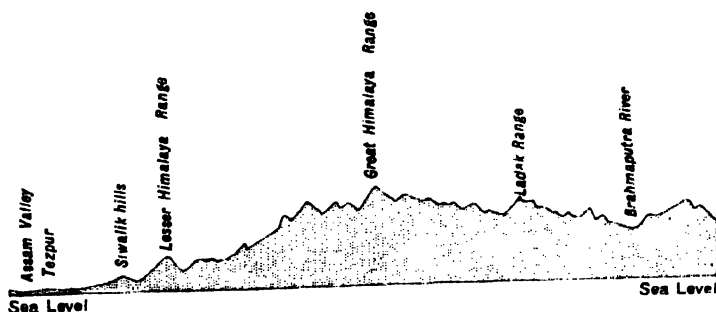
FIGURE 1.

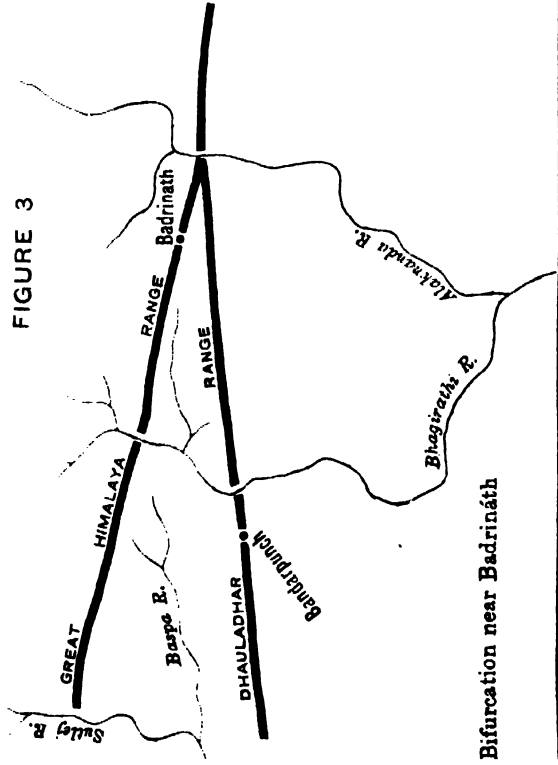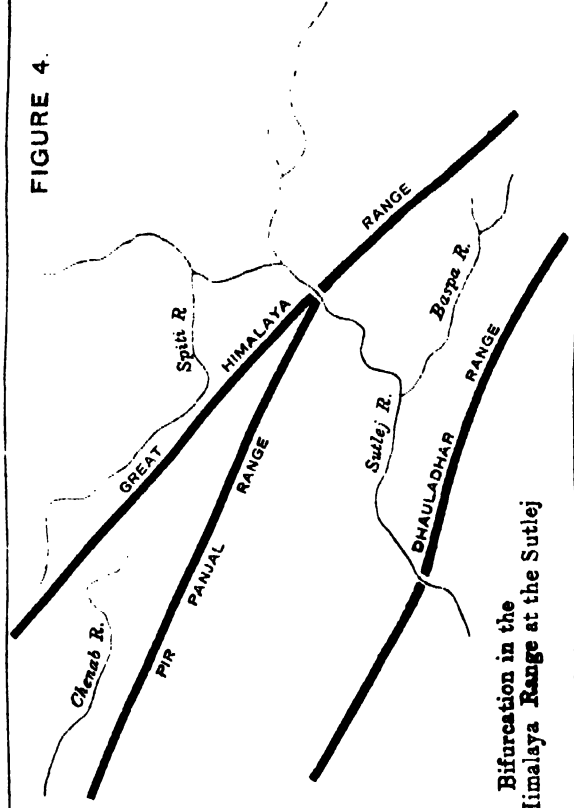Bifurcation near Dhaulagiri

FIGURE 2.

Bifurcation near Nampa
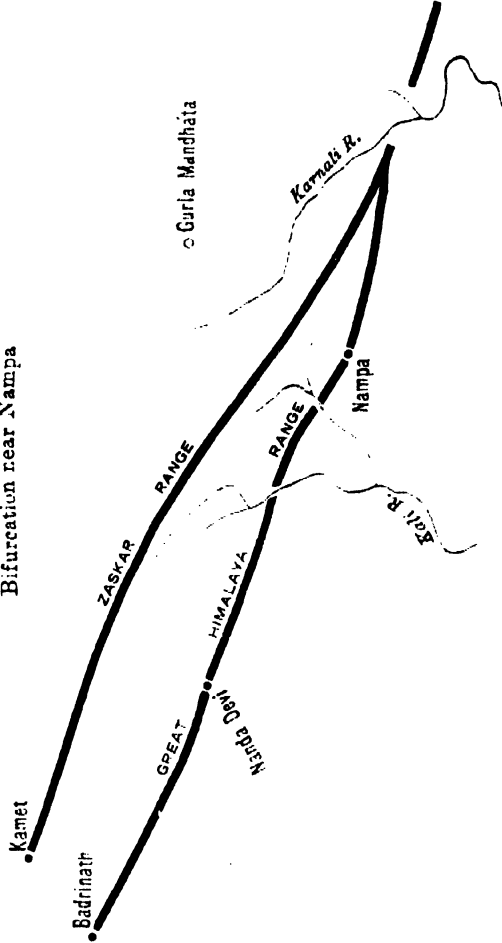
FIGURE 3.

Bifurcation near Badrináth

FIGURE 4.
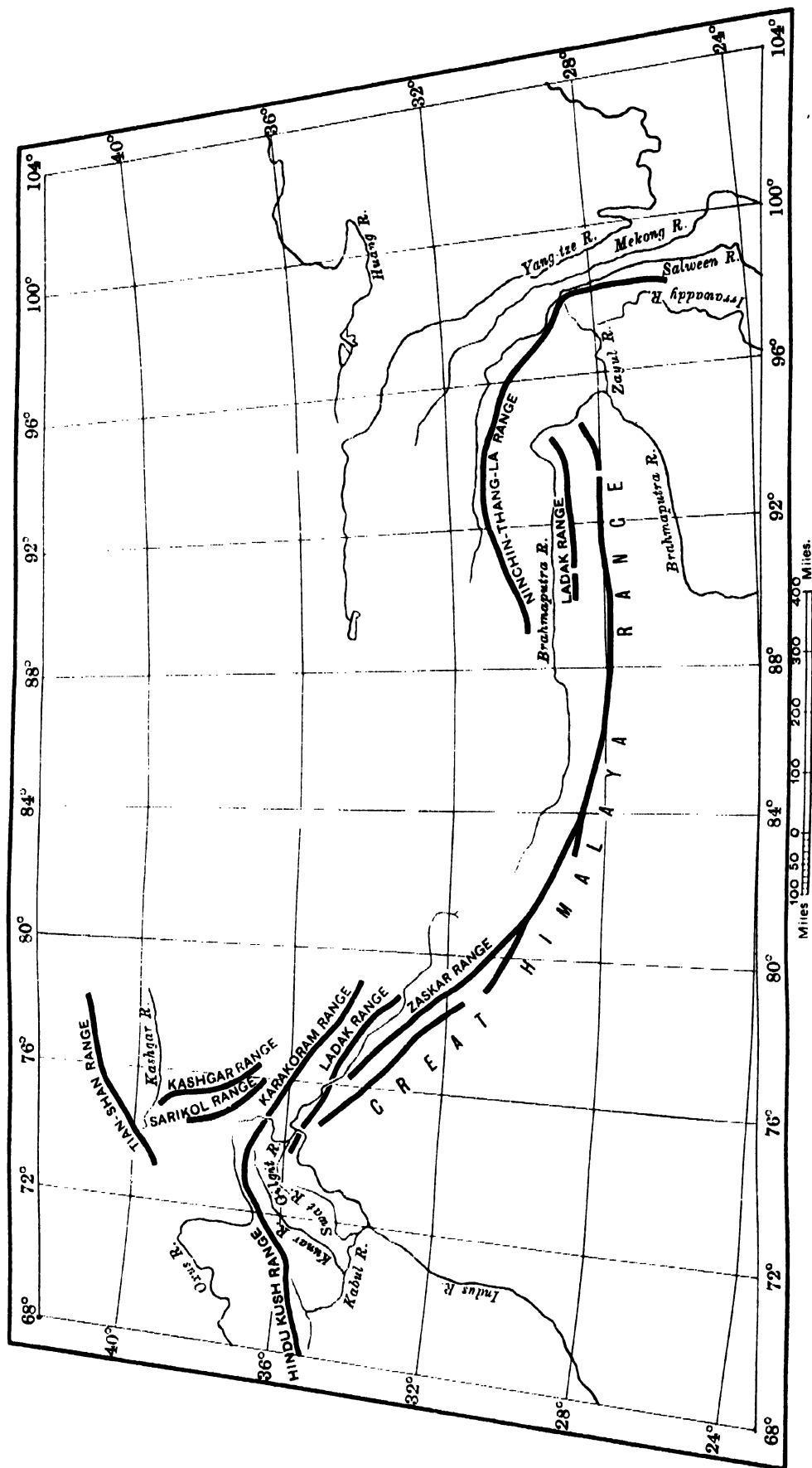
Bifurcation in the
Great Himalaya Range at the Sutlej

CHART

to illustrate

how the GREAT HIMALAYA RANGE

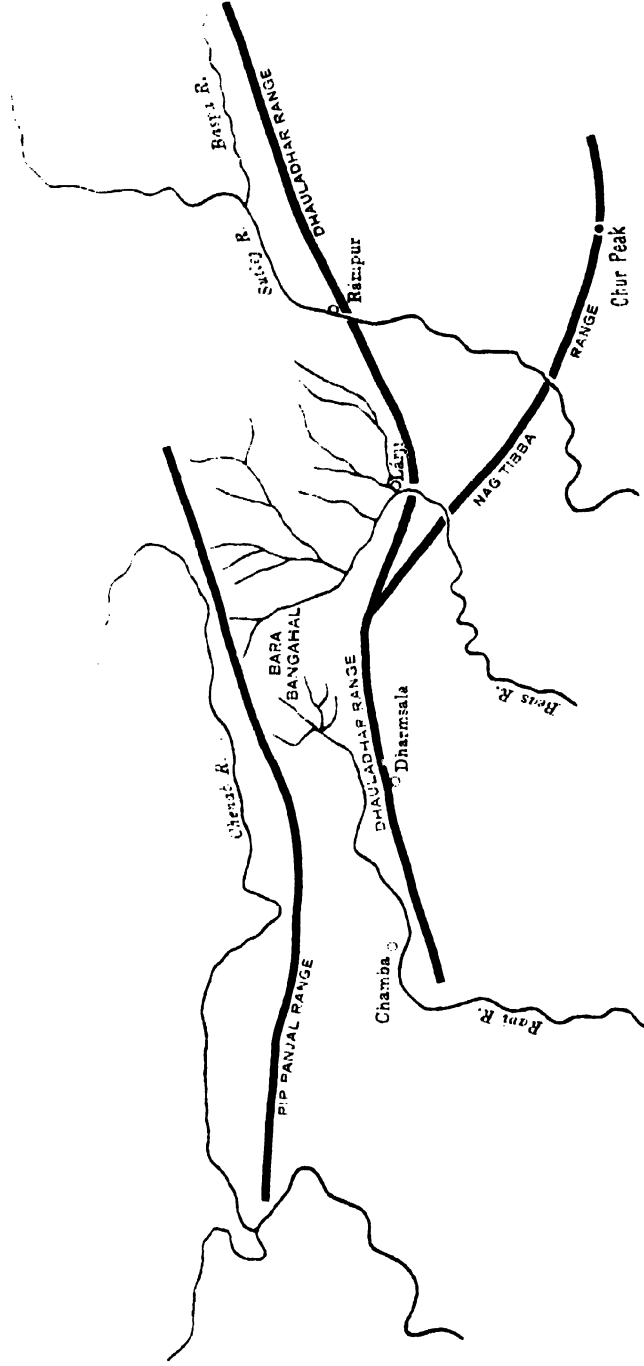terminates firstly at the INDUS secondly at the BRAHMAPUTRA

CHART XVII

CHART XVII

Conjunction of Ranges at the Source of the
RAVI

Scale 1" = 32 Miles

DHAULADHAR RANGE

Barri R.

Sutej R.

Rampur

Chur Peak

RANGE

NAG TIBBA

Beas R.

BARA
BANGAHAL

DHAULADHAR RANGE

Dharmsala

Chenat R.

Chamba

Ravi R.

PIP PANJAL RANGE

Lessons from the SIWALIK Range

CHART XIX

FIGURE 1.

Bifurcation of the Siwalik Range
South of Kángra
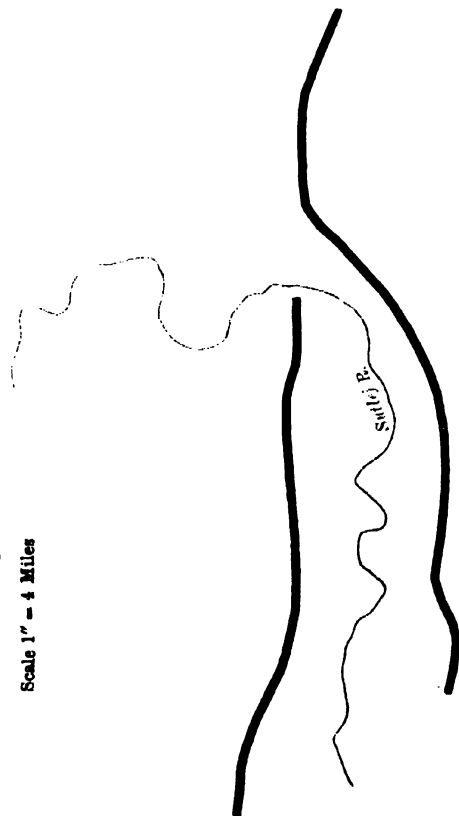
Scale 1" = 4 Miles

FIGURE 2.

Passage of the
Sutlej through the Siwalik Range
at the place where the range
alters its alignment

Scale 1" = 32 Miles

Sutlej R.
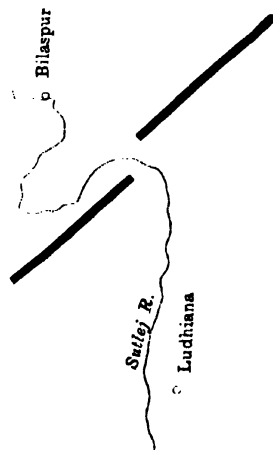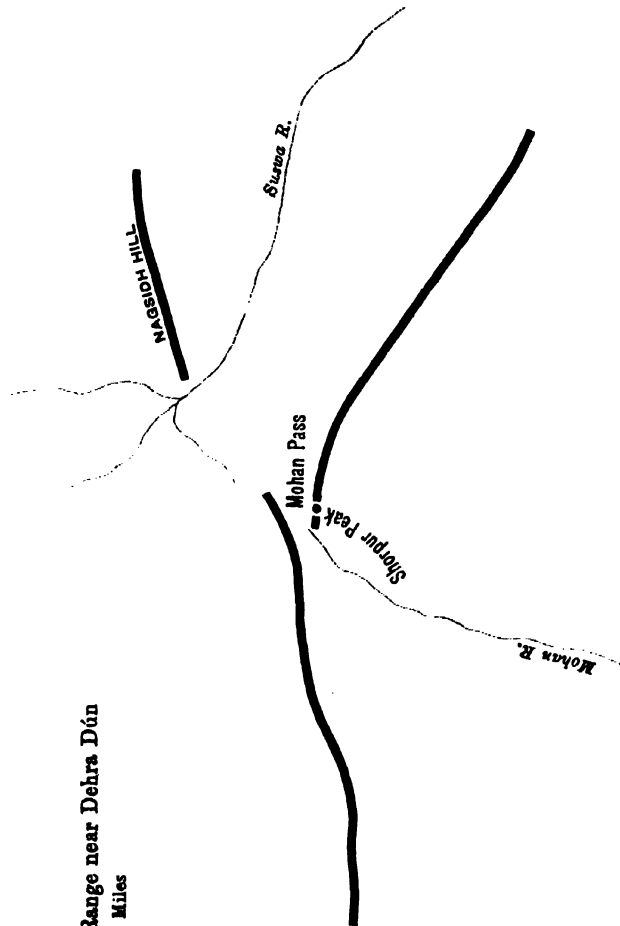
○ Ludhiana
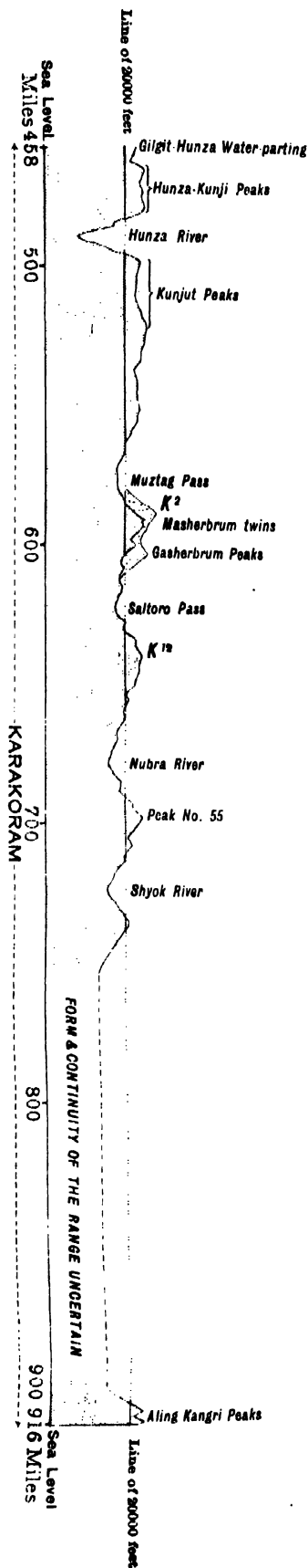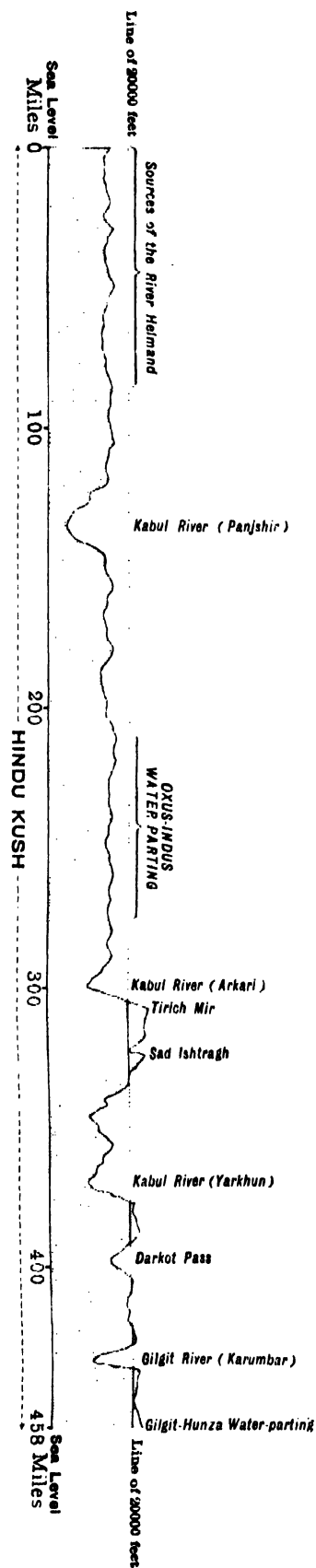
○ Bilaspur

FIGURE 3.

Bifurcation of the Siwalik Range near Dehra Dún

Scale 1" = 4 Miles

NAGSIOH HILL

Suswa R.

Mohan Pass

Shopur Peak

Mohan R.

SECTION
along the crest-line of the
HINDU KUSH-KARAKORAM RANGE
from Afghanistan to Tibet
showing how the range is being cut
by rivers into isolated blocks

Line of 20000 feet

Sources of the River Helmand

Sea Level
Miles 0

OXUS-INDUS WATER-PARTING

Kabul River (Panjshir)

HINDU KUSH

Kabul River (Arkari)
Tirich Mir

Sad Ishtragh

Kabul River (Yarkhun)

Darkot Pass

Gilgit River (Karumbar)

Gilgit-Hunza Water-parting

Line of 20000 feet

Sea Level
458 Miles

Line of 20000 feet

Gilgit-Hunza Water-parting

Hunza-Kunji Peaks

Hunza River

Kunjut Peaks

Muztag Pass
K^2
Masherbrum twins
Gasherbrum Peaks

Saltoro Pass

K^{12}

Nubra River

Peak No. 55

Shyok River

Aling Kangri Peaks

FORM & CONTINUITY OF THE RANGE UNCERTAIN

KARAKORAM

Sea Level
Miles 458

500

600

700

800

900 916 Miles

Line of 20000 feet

Sea Level
900 916 Miles

SCALES

Vertical

Feet 40000 20000 0 40000 Feet

Horizontal

Miles 64 48 32 16 0 64 128 Miles

CHART XXI

FIGURE 1.

Conjunction of the KAILAS and LADAK,
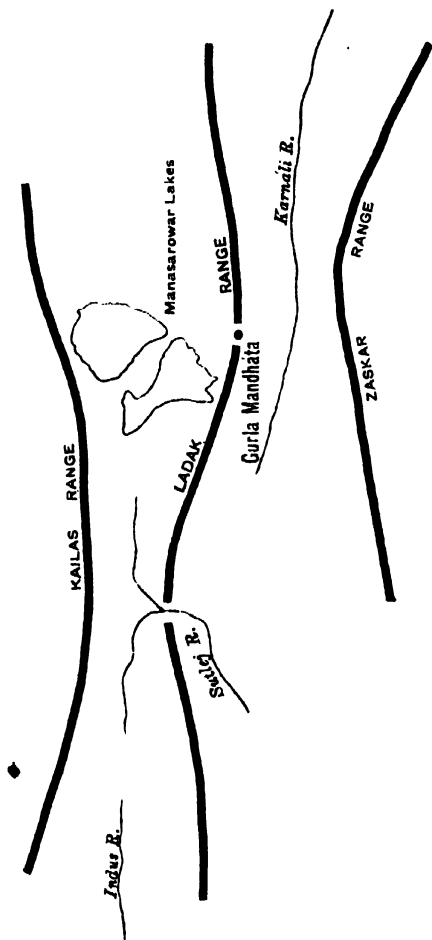also of the LADAK and ZASKAR Ranges
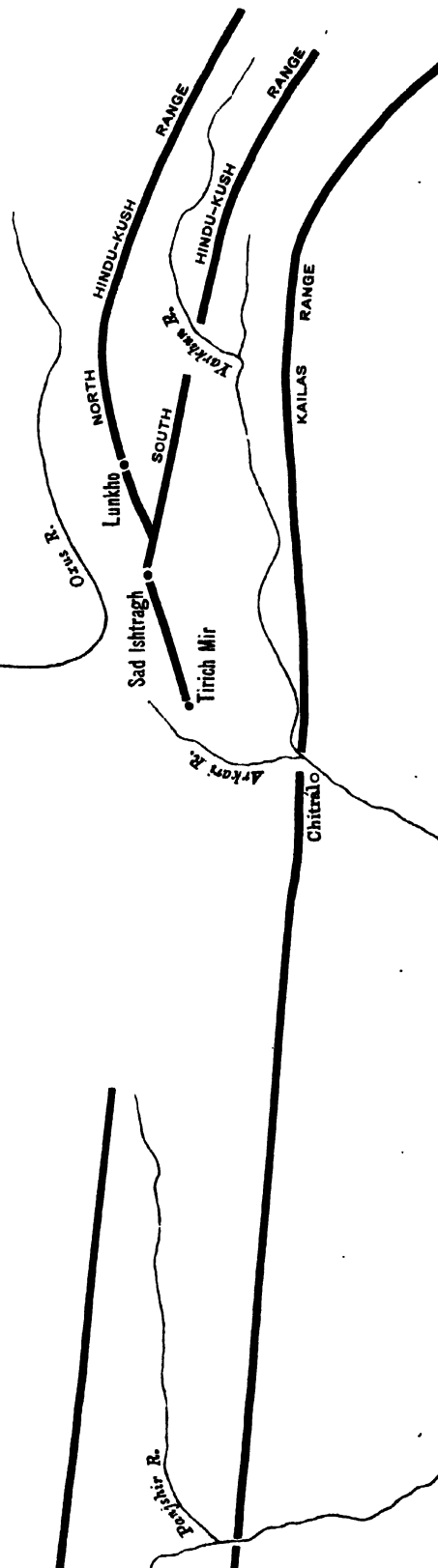
Scale 1″ = 32 Miles

FIGURE 2.

Conjunction of the two HINDU-KUSH Ranges
at TIRICH MIR

Scale 1″ = 32 Miles

CHART XXII

ROUTES of EXPLORERS in TIBET 1865 to 1905

PLAINS OF TARIM

PLAINS OF INDIA

SURVEYED

SURVEYED

O Kashgar

O Cherchen

Leh O

O Gartok

O Lhasa

Batrang O

O Darjeeling

Scale 1 Inch = 256 Miles

Limits of the region of mountains ....

Tracks of Explorers ————